12780

INDIAN CHRONOGRAPHY

AN EXTENSION OF THE "INDIAN CALENDAR" WITH WORKING EXAMPLES

BY

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ERRATA.

P. 6, line 21 f.— *For* "Tuesday" *read* "Monday."
Id. id. 22.— *For* "with the 588,466th day" *read* "with the day 588,466 elapsed, 588,467 current."
P. 8, Note 3, line 1.—*For* "1" *read* "2."
P. 10, line 6.— *For* "The Siddhânta" *read* "Muñjâla, as quoted in the Siddhânta."
Id. id. 12.— *For* "suspicious" *read* "auspicious."
P. 13, Note, line 11.— *For* "1109" *read* "1809."
P. 18, line 17.— *For* "4.20" *read* "4.42."
P. 28, Art. 48, line 5.— *For* "p. 25" *read* "p. 26."
P. 32, line 15.— *For* "Vilâyatî" *read* "Amli."
P. 37, Note 2, line 1.— *Omit* "superior," *and for* "conjunctions" *read* "conjunction."
Do. do. line 2.— *For* "or" *read* "and also."
P. 40, Note 2, last line but one.—*For* "however" *read* "also."
P. 41, Note 4.— *For* "Note 3, p. 31" *read* "Note 2, p. 32."
P. 42, line 15.— *For* "above" *read* "below."
P. 44, line 29.— *After* "Fasali year" *add* "1300."
Id. line 30.— *For* "1882" *read* "1892."
P. 45, line 11.— *For* "599" *read* "599—600."
Id. line 4 from bottom.—*For* "three cycles" *read* "two cycles."
P. 55, line 8.— *For* "Śaka 496" *read* "Śaka 419."
P. 57, Foot.— *For Note* "4" *read* "2."
P. 58, Art. 104, line 2.—*After* "below" *add* "it."
Id. Art. 104 (*b*), line 3.—*After* "given year the" *add* "second, otherwise the first."
Id. id. line 4.—*For* "O/I" *read* "O."
Id. id. lines 4,5.—*Omit the sentence* "in the reverse . . . by one."
P. 59 (*b*), line 3.— *After* "given year the" *add* "second, otherwise the first."
Id. id. line 4.— *For* "O/I" *read* "O."
Id. id. id. — *Omit the sentence* "in the reverse case . . . by one."
P. 62, Note 1.— *Omit* "11."
P. 63, Art. 121.— *For* "(2)" *read* "(3)."
P. 72, Note, line 2.— *For* "(p. 75, Note 2)" *read* "(p. 77, Note 4)."
P. 74, Example 11, *Answer*.—*For* "(see Example 1, above)" *read* "(see Examples, pp. 66, 67)."
P. 87, line 13.— *After* "month" *add* "*i.e.*, the moment of the sankrânti."
P. 93, Note 2.— *For* "4" *read* "3."
P. 94, line 1.— *After* "month" *add* "*i.e.*, the moment of the sankrânti."
P. 98, line 6.— *For* "xviii." *read* "xxiii."
P. 105, Rule 3.— *For* "167" *read* "168."
Table I., p. iii., cols. 21, 22, 24, 25.—*For* "34," ".102," "895," "256," *respectively, read* "35," ".105," "896," "255."
P. cvi., Table II., Part III.—*Add* "N.B. iii.—Figures in this Table and in Table I. are given on the supposition that the Śaka and Vikrama years which are in use at the present day are expired years, and the rest current ones."
Table IX., pp. cxvi., cxvii.—The figures given are for days in common years. For dates after February 29th in a Leap-year the number given must be advanced by 1. Thus, the number for July 1st in a Leap-year is 183, for September 18th, 262, &c.
Table W., *Additions and Corrections*, p. 158—*Under the heading* "Sûrya Siddhânta," *sub-column* "degrees," *opposite the year* "70," *for* "14" *read* "24." *In the last column of the heading Table, opposite* "Sûrya Siddhânta with bîja," *for* "4″" *read* "44″."

ADDITIONAL NOTES.

In § 44 (i), p. 19, I have stated, in accordance with § 96 and Table, pp. 54, 55 of the *Indian Calendar,* that the difference in the moment of true Mēsha saṁkrānti of A.D. 496, as calculated respectively by the *First Ārya* and *Present Sūrya Siddhāntas* was nil, while there was a real difference in every other year. As I find that some doubt exists on that point I have been at pains to ascertain the truth. The following computation proves the correctness of my statement. I use Dr. Fleet's method (*text, p.* 56, *note* 2) and Dr. Schram's Julian Calendar Tables. The year K.Y. 3597 ended in A.D. 496.

Ārya Siddhānta.

Sunrise epoch of the K.Y. in elapsed days of Julian period, at mean sunrise on February 18, 3102 B.C.		588,466.0000000
1 year . .	365.2586805 × 3597	
	1,313,835.4739583 . . .	1,313,835.473958$\dot{3}$
		1 902,301.473958$\dot{3}$
0 March, A.D. 496		1,902,281.0000000
Mean Mēsha saṁk., March . . .		20.473958$\dot{3}$
Deduct śōdhya		—2.147569$\dot{4}$
True Mēsha saṁk., March . . .		18.3263$\dot{8}$

Sūrya Siddhānta.

Midnight epoch of the K.Y. in elapsed days of Julian period, at previous midnight		588,465.7500000
1 year . .	365.25875648$\dot{1}$ × 3597	
	1,313,835.747063$\dot{8}$ . .	1,313,835.747063$\dot{8}$
		1,902,301.497063$\dot{8}$
0 March, A.D. 496		1,902,281.0000000
Mean Mēsha saṁk., March . . .		20.497063$\dot{8}$
Deduct śōdhya		—2.170694$\dot{4}$
True Mēsha saṁk., March . . .		18.326369$\dot{4}$

By both authorities, therefore, true Mēsha saṁkrānti occurred on March 18th, A.D. 496; but the *Ārya Siddhānta* fixes the time as 7 h. 50 m., while the *Sūrya Siddhānta* fixes it as 7 h. 49 m. 58.32 s. (I convert the decimals to time by Table XXXVI.). The difference between them only amounts to 1.68 s., and this slight disagreement would perhaps disappear if we could determine the value of the śōdhya by the two authorities with absolute exactness.

II.

Extension of Example 1, *p.* 81.

Example 1 only deals in whole minutes. Where seconds are required, for closer calculation of the moment of any Mēsha saṁkrānti according to the *Sūrya Siddhānta,* the process will be as follows:

Rule. Take down the time according to the *Ārya Siddhānta* from cols. 13–17 of Table I., and add, if necessary, the 30 seconds requisite, as shewn in "Hint" No. 20, p. 79. Referring to the Table on p. 55 of the *Indian Calendar,* calculate the Siddhānta difference for the interval of years between A.D. 496 and the given year, and apply it to the former figure, after converting the decimals of a minute into seconds. The result gives the moment of Mēsha saṁkrānti according to the *Sūrya Siddhānta* in seconds as well as minutes.

Wanted, the moment of true Mēsha saṁkrānti by the *Sūrya Siddhānta* in A.D. 1613, which the *Indian Calendar,* Table I., cols. 13 and 17*a*, fixes as March 28th at 8 h. 35 m.

	h.	*m.*	*s.*
True Mēsha saṁk. by the *Ārya Siddhānta,* adding 30 seconds as required by "Hint" No. 20 . . . . 28 March	6	32	30
Difference of years (1613 — 496 =) 1,117. By Table on *Indian Calendar,* p. 55.			
yrs. *diff.*			
900 = 98.4			
200 = 21.9			
10 = 1.1			
7 = 0.8			
1,117 = 122.2 (.2 = 12 s.)	2	2	12
True Mēsha saṁkrānti by the *Sūrya Siddhānta*	8	34	42

The exact moment required was, therefore, 28th March, A.D. 1613, at 8 h. 34 m. 42 s.

INDIAN CHRONOGRAPHY

PREFACE.

I DESIRE to record my respectful acknowledgments for their support and encouragement, without which this book could not have been published, to the Right Hon. The Secretary of State for India in Council, and H.E. The Governor of Madras in Council; as also my cordial thanks to those who have from time to time favoured me with their help and advice. Dr. J. F. Fleet has assisted me from beginning to end in many ways, and I cannot too strongly express my obligation to him: he has not only given me throughout the benefit of his extensive knowledge of the subject, but has taken the trouble to assist me in the often wearisome work of correcting the proofs: while, however, he has supplied me with a few bases for work and some notes, remarks and suggestions, he is not to be held in any way responsible for the methods and teaching in this volume, which are my own. Dr. Robert Schram has devoted many days of hard labour to elaborate calculations for ascertaining the correct value of the śōdhya, an important element for some astronomical processes, at the beginning of the Kaliyuga; and I have also to thank him for his permission to reprint his Table (Table XXIII. of the present Volume) for simplifying the calculation of nakshatras. Mr. A. C. D. Crommelin, of the Greenwich Observatory, was kind enough to advise me in the matter of the late Mr. Sh. B. Dikshit's method of computing the longitudes of Jupiter. My acknowledgments are due to Professor Hermann Jacobi of Bonn for his generous permission to adopt some of the Tables published by him in the *Epigraphia Indica, Vols. I., II.*, and the *Indian Antiquary, Vol. XVII.*, and to reproduce them; but I have not found it necessary to do so for general purposes, and for special purposes have thought that the more proper course for me is simply to refer the reader to the Professor's publications. I have, however, made use of Tables 5 and 6 of his *Indian Antiquary* article on "Methods and Tables for Verifying Indian Dates" (Vol. XVII., pp. 163, 164), modifying them as explained in §§ 85A to 85C of the Text; and I must tender him my sincere thanks for his permission to do so. Finally, I have to thank Messrs. Thacker, Spink & Co. of Calcutta for permission to reprint, from General Sir Alexander Cunningham's *Book of Indian Eras*, the Tables here numbered XLI.A. and XLI.B.

R. SEWELL.

INDIAN CHRONOGRAPHY.

INTRODUCTORY.

1. The *Indian Calendar*, the joint work of the late Mr. Shankar Balkrishna Dikshit[1] and myself, has now been before the public for fifteen years. It has been extensively used by the leading epigraphists of the day, and from the absence of adverse criticism I trust I am justified in assuming that it has, on the whole, merited their approbation. Its defects are partly due to the difficulty of the subject with which it was intended to deal. Of misprints, I hope and believe that there are few besides those given in the "Errata" list on p. XI. above.

2. But I am advised that the *Indian Calendar* is by no means free in places from a certain amount of obscurity and that its processes have not been quite sufficiently explained in the text—a defect which (without at all wishing to be controversial I may perhaps be permitted to plead) it shares with every other work yet published on the same subject.

3. The present volume is intended partly to remedy that obscurity. It is also designed, by offering some further Tables which it is hoped will be found useful and time-saving, to assist not only epigraphists, but also those engaged in testing the genuineness of ancient documents relied on in the Law Courts, to whom it must always be troublesome to have constantly to turn from one volume to another and who may be in the habit of using the *Indian Calendar*. Lastly its object is to help those as yet not greatly experienced in making chronological calculations by giving them a series of fully-worked examples. In these examples and in the text which precedes them an attempt has been made to explain fully and clearly the reasons for every process adopted, and the basis of formation of the Tables. A set of new Tables for finding the true and mean longitude of Jupiter at any moment is appended, as well as for testing the correspondence of the Jovian saṁvatsara with the current solar or luni-solar year. Other Tables are added as aids by the way. I desire to state once for all that I have no intention whatever of impugning the accuracy of other works on the subject, or of claiming the slightest superiority for our *Indian Calendar* methods over those of Professor Hermann Jacobi and others. In all cases of doubt or difficulty Professor Jacobi's "Special Tables" in the *Epigraphia Indica*, Vol. I., pp. 403 ff, which determine longitudes in degrees, minutes and seconds, should be resorted to. The *Indian Calendar* system, which followed Professor Jacobi's former Paper and Tables in the *Indian Antiquary* in basing its calculations on what may be called the "*a, b, c*" method, has for its time-unit a unit of about $4\frac{1}{4}$ minutes. This is usually quite accurate enough, and the method has the advantage of being simple and easy to manipulate.

[1] In this Volume I employ the customary spelling of the name.

4. The Hindū standard astronomical works with which the present volume is principally concerned are the *First Ārya Siddhānta* of Āryabhaṭa[1] (date about A.D. 499), and the *Present Sūrya Siddhānta*, which has been in use in large parts of India since about A.D. 1100. These are the works respectively meant in these pages whenever the terms "The Ārya Siddhānta" and "The Sūrya Siddhānta" are used. When allusion is made to the bīja or correction introduced into the latter from about A.D. 1500 the fact is always expressly stated. The *Original Sūrya Siddhānta* (in use before about A.D. 550), the *Brāhma Siddhānta*, the *Second Ārya Siddhānta* and others are always mentioned with their full titles.

Whenever the word "*saṁvatsara*" is used in these pages with no qualification the Jovian or Bṛihaspati saṁvatsara is meant, *i.e.*, the average period during which Jupiter remains by his mean motion in a sign of the zodiac, or one-twelfth of the great circle on the plane of the ecliptic.

5. Table I. of the *Indian Calendar* contains (Cols. 8 to 12 and 8A to 12A) the figures which, by the *a*, *b*, *c* system, prove which lunar months were intercalated or suppressed by both the true and mean systems from K.Y. 3401 expired (A.D. 300), down to K.Y. 4201 (A.D. 1100); and thereafter, down to K.Y. 5001 expired (A.D. 1900), by the true system only; but as the opinion has been growing of late years that in many parts of India the use of the mean system may have been prolonged for a considerable time subsequent to A.D. 1100, it has become necessary to devise rules and tables by which a result, given or obtained, by the true system may be easily and accurately converted into a result by the mean system, and *vice versa*.

For similar reasons it is advisable to have at hand an easy method for converting the time of solar saṁkrāntis as found by either the *Ārya* or the *Sūrya Siddhānta* into the time according to the other. The present Tables and Rules supply this want.

5A. I may add that for a general sketch of the Hindū calendar, eras, and other reckonings, which is calculated to be of considerable use to students as a preliminary study before they attempt to apply to practical use the teaching of my two books on the subject, reference may be made to Dr. Fleet's article on "Hindū Chronology" in the recently published new edition of the *Encyclopædia Britannica*.

DATES OF EARLY INSCRIPTIONS.

6. Before proceeding further a few notes on the dates of early inscriptions may be found useful. These notes are based on the late Professor Kielhorn's Lists of the Inscriptions of Northern and Southern India, respectively published as Appendices to the *Epigraphia Indica*, Vols. V. and VII. (1898–99, 1902–3), and therefore refer only to such inscriptions as were known to him, or at least which had been examined and finally recorded by him. In these publications he has included 1806 inscriptions. Many thousands of others are known to exist, and therefore the remarks which follow must only be regarded as temporary and provisional. I omit all inscriptions regarding which a doubt exists, or which are not accepted as genuine by the best authorities.

7. The earliest genuine inscription-date in the Mālava-Vikrama era is contained in the engraved pillar-record of the Varika Rāja Vishṇuvardhana at Bijayagaḍh in Rājputānā.[2] The stated year,

[1] I am indebted to Dr. Fleet for a suggestion that in future the *First Ārya Siddhānta*, as so called in the *Indian Calendar* and in this work, should be described by its "correct name"—the "Āryabhaṭīya," and that the *Second Ārya Siddhānta* should be known as the "Ārya Siddhānta." The suggestion comes too late for me to make any use of it; and for the reasons given in the note preceding Table XXXVII., I prefer to attempt no such alteration in the present volume. (See J. R. A. S. 1911, p. 114.)

[2] It was published by Dr. Fleet, *Gupta Inscriptions* (Corpus. Inscr. Indic. III.), No. 59, p. 252. Kielhorn's Northern List, No. 1.

428 expired, is in this reckoning, though the era itself is not mentioned. The date does not admit of exact verification, being simply "Phālguna kṛ. 15," the new-moon day of probably pūrṇimānta Phālguna (amānta Māgha). The reckoning was luni-solar and the A.D. year is 372.

8. The earliest known *definite* mention of this Mālava era is in the Mandasōr (Mālwā) inscription of Kumāragupta I. of a date falling in December A.D. 436. [1] The month and day are stated in luni-solar reckoning, the months, two in number, being given the old season-names "Sahasya" and "Tapasya" for the more modern Pausha and Phālguna. (*List in Indian Calendar, p.* 24, § 41.)

9. The earliest known mention of the Kalachuri-Chēdi era, in an inscription undoubtedly genuine, is found in the Pārḍī (Surat) plates of the Mahārāja Dahrasēna which bear a date in the year 207 falling in A.D. 456 or 457. The reckoning is luni-solar. [2]

10. The earliest mention of the Śaka era in a genuine inscription is found in the Bādāmi cave-inscription of the Western Chalukya prince, Raṇavikrānta Maṅgalēśvara, afterwards king, dated in Śaka 500 (expired), or A.D. 578. [3] The day was the full-moon day of Kārttika. The reckoning was luni-solar. In Northern India the earliest mention of this era is found in the Dēōgaḍh (Lalitpur, Central Provinces) Jaina inscription of Śaka 784 (expired), A.D. 862, where it is given as subsidiary to the real date in the Vikrama era. [4] The next known instance of its use in the north, except in Kāṭhiāwār and Gujarāt, is in A.D. 1137–38. On this era see Fleet (*J. R. A. S., July*, 1910, *pp.* 818–24.)

11. The Kaliyuga era is not often mentioned in inscriptions. The earliest such date is in the Aiholẹ inscription of Pulakēśin II., the Western Chalukya king, which belongs to A.D. 634–35.[5] The next instance known is of A.D. 770; the next of 866. These are in Southern India. In Northern India the earliest known instance occurs in A.D. 1169 or 1170.[6] On the general subject of this era see Dr. Fleet's articles in *J. R. A. S.*, 1911, pp. 479 ff., 675 ff.

12. With regard to the sixty-year cycle of Jupiter the question as to the earliest known mention of it is somewhat doubtful. In Kielhorn's "Southern Inscription List," p. 3, No. 5, is noted a pillar-inscription of the W. Chalukya king Maṅgalēśa at Mahākūṭa, near Bādāmi, the date of which is stated as on the full-moon day of Vaiśākha in the fifth year of his reign, *pravarttamānē Siddhārthē*, which has been translated "in the current Siddhārtha (saṁvatsara)" and "in (the year) Siddhārtha being current," with the effect of placing the record on 12th April, A.D. 602. Dr. Fleet published this inscription in *Ind. Ant.* XIX., p. 7 ff. Professor Kielhorn, in his last reference to this record, used the words "Siddhārtha, if it is really intended here," implying that he was not perfectly assured on that point (*List, quoted, No.* 5). But Dr. Fleet has reiterated his opinion (*Ind. Ant.* 1903, *Vol. XXXII., pp.* 214–15), and fortifies his argument by pointing out that fifty years earlier the names of all the sixty saṁvatsaras of the Jovian cycle were fully recited by Varāhamihira (viii., vv. 28–52), who died in A.D. 587. The use of the cycle was well established by A.D. 550. If, however, we set aside this record, then the earliest known mention of a year of the cycle occurs in the Alās plates of the Rāshṭrakūṭa king Gōvindarāja II., where the saṁvatsara "Saumya" is given, with details falling in A.D. 770.[7]

[1] Kielhorn's Northern List, No. 3. Fleet, *Gupta Inscrs.*, No. 18, p. 79.

[2] *Epig. Ind.* Vol. X., p. 51. Kielhorn's List of Inscriptions of Northern India, p. 55, No. 391.

[3] Kielhorn's Southern List, p. 2, No. 3. As I have explicitly stated in the text the dates here given are the earliest mentioned in the *inscriptions known to Prof. Kielhorn*. Dr. Fleet (*J. R. A. S. for* 1910, *p.* 819) has called attention to the Śaka date 427 (A.D. 505) given in Varāhamihira's *Pañchasiddhāntikā* as the earliest known certain date up to the time of his article. But Mr. R. Narasimhachar has brought to notice a Sanskrit work entitled *Lōkavibhāga* which bears date Śaka 380 (expired), = A.D. 458–59, and in the twenty-second year of Śiṁhavarman, king of Kāñchī. (See his Annual Report, Mysore, for 1908–9, §§ 35, 112.)

[4] Kielhorn's Northern List, No. 14, p. 4. *Epig. Ind.*, IV., 310.

[5] Fleet, *Ind. Ant.* VIII. 237 ff. J. R. A. S., 1911, p. 689; Kielhorn, *Epij. Ind.* VI. 1 ff.

[6] Jour. R. Asiat. Soc., July 1911, p. 689.

[7] Kielhorn's Southern List, No. 56, p. 10. *Epig. Ind.*, VI., 209

13. The earliest inscription-date known to Professor Kielhorn which was certainly given in amānta lunar-month reckoning, and which belongs to a genuine inscription of India Proper, bears date corresponding to 4th May, A.D. 794. It is contained in the Paiṭhaṇ plateṣ of the Rāshṭrakūṭa king Gōvinda III. (*Epig. Ind., III.*, 105; *Ind. Ant. XVII., p.* 142, *No.* 9.)

13A. From Kielhorn's "Lists" for Southern India I find that in all the early Chalukya and Rāshṭrakūṭa inscriptions dates are stated in lunar reckoning with luni-solar years; solar months and days not being mentioned. This practice seems to have been general in earlier times in the south. The recording of the occurrence of saṁkrāntis begins apparently in about the ninth century, becoming common only after the close of the eleventh century A.D. The earliest mention of the solar saṁkrānti in an undoubtedly genuine inscription of the Western Gaṅgas is met with in A.D. 975. The Kalachuri records mention saṁkrāntis from about A.D. 1150, but continue afterwards, as before, to name no solar month. The Śilāhāra records follow the same practice, the first of their inscriptions that mentions a solar saṁkrānti being one of A.D. 997. Saṁkrāntis are alluded to very sparingly in inscriptions of the Yādavas of Dēvagiri, and only after A.D. 1200. The Hoysaḷas of the Maisūr country took notice, after about A.D. 1050, of the lagnas of the solar signs; but from the middle of the thirteenth century the solar months are regularly named after the Tamil fashion, and in several inscriptions after that date they use the Tamil names for the solar months. Even the Vijayanagar kings, whose accession to power began in the fourteenth century, appear to avoid all mention of solar months except in their inscriptions in the Tamil country. The Eastern Chālukyas of the Telugu tracts mention solar signs and months after about A.D. 950, but as additions to the principal part of the date, which was given in lunar reckoning. No mention of saṁkrāntis or solar months occur in inscriptions of the ancient Pallavas, Kadambas, and Bāṇas. For the last ten centuries or so, however, the Tamils proper have stated their dates in their own fashion, which includes full solar as well as lunar reckoning. They generally state first the week-day and current nakshatra, then the number and fortnight of the tithi current at or very shortly after sunrise, coupling this tithi not with its lunar month name but with the name of the current solar month. Occasionally the serial day of the solar month is recorded. West-Coast inscriptions are often dated in the fashion of the Tamils, but in that country they seem to have paid closer attention to the position of Jupiter than the Tamilians did. In North-Western India the usual reckoning was luni-solar, and in North-Eastern India solar.

Reckoning adopted in different tracts.

The only saṁkrāntis which appear to have been much considered from the tenth to the thirteenth centuries were the solstitial ones, the Uttarāyaṇa and Dakshiṇāyana saṁkrāntis, of which the former was by far the most important. Afterwards the equinoctial saṁkrāntis, Mēsha and Tulā, were taken into account; and later on we find occasional mention of the other saṁkrāntis.

The use of names for week-days is also a matter to be noticed when dealing with early inscriptions. The earliest instance, in Kielhorn's Lists, of the use of the week-day is found in A.D. 484 (*Northern List, No.* 454); the next occurs in A.D. 664 (*Southern List, No.* 550); the next in A.D. 692 (*ibid. No.* 29). The use of it became general only after about A.D. 900. The first is a Gupta inscription from the Sāgar District of the Central Provinces; the second belongs to the Nellore District, Madras Presidency; and the third to the neighbourhood of Banawāsi in North Kanara. The citation of the week-day in a date professedly earlier than about A.D. 400 at once raises a suspicion as to the genuineness of the record.

These notes may help workers to judge of the authenticity of some documents or records which claim to be of great age.

EXPLANATIONS AND DEFINITIONS.

14. The Hindūs assumed that the earth was the centre of the visible universe and was itself stationary, the sun revolving round it like a superior planet. They divided the great circle of the sun's path into twelve zodiacal signs, each of 30° of arc, the first of which was called Mēsha; but prior to this by many centuries they had divided the same circle into 27, or sometimes 28, nakshatras or lunar asterisms, observing the moon's path in the heavens and allowing roughly an asterism to each day of her average journey round the earth in the course of a sidereal month. The first point of the first sign Mēsha is the point from which all celestial longitudes are measured, its employment corresponding in this respect to the first point of Aries in European astronomy, though it is not at all in the same position. This first point of Mēsha corresponds to the point at the end of the nakshatra Rēvatī and the beginning of the nakshatra Aśvinī. (*See below under "Nakshatras."*) It is considered to be an immovable sidereal point, according to some authorities coincident with the principal star of the nakshatra Rēvatī, but according to the *Sūrya-Siddhānta* lying 10′ to the east of that star. The star has been identified with ζ Piscium, a star lying almost on the ecliptic, which was found to be a convenient point from which to take measurements. It will be observed that, since the first point of Mēsha is fixed and immovable, the Hindūs have not as a rule paid attention to the precession of the equinoxes. The Hindū solar year is therefore always considered as sidereal unless special mention is made of its being treated as tropical. The first point of Mēsha is considered by the *Sūrya Siddhānta* to have coincided with the vernal equinox in A.D. 499, by almost all the other authorities in A.D. 522, but by the *Siddhānta Śirōmani* in A.D. 527. In the year of coincidence the sidereal signs were exactly the same as the tropical signs, or the signs whose initial points are calculated with reference to the precession of the equinoxes.[1]

The sun, passing in its annual course completely round from and to the sidereal First Point of Mēsha, enters and leaves in turn each of the twelve signs. This complete revolution is of course due to the sidereal revolution of the earth about the sun, and its length in time constitutes the length of the solar sidereal year. (*The tropical year is separately considered below under the head of "Tropical Saṁkrāntis."*) The solar sidereal year is the ordinary solar year of the Hindūs. It is divided into twelve months, the length of each of which, its time measurement being calculated by the time occupied by the sun in passing completely through one sign or 30° of arc, differs from the others in consequence of the earth's orbit being an ellipse. The moment of the sun's entering each of the signs in turn marks the astronomical beginning of a true or apparent solar month, and this "coming together" of the sun and the sign is called a "saṁkrānti." Since it is evident that the sun's entry into each sign in succession may be calculated by his mean longitude at the moment of such entry as well as by his true longitude, we have sometimes to calculate the moments of occurrence of mean saṁkrāntis as well as of true or apparent ones. But throughout this volume, unless clearly designated and distinguished as "mean," the word "saṁkrānti" means a true or apparent sidereal saṁkrānti, *i.e.*, the junction of the sun in its course with the first point of each sign as calculated by the sun's (earth's) true motion and without reference to the precession of the equinoxes. When the precession of the equinoxes is taken into account the saṁkrānti is called a "tropical saṁkrānti." The true sidereal day is the time occupied by a meridian on the earth's surface in completing one revolution about the earth's axis. A solar sidereal month is a month of thirty sidereal days. But neither of these is used in the Hindū

[1] For an excellent notice of the nakshatras reference may be made to Whitney's *Oriental and Linguistic Studies*, s.v., "The Lunar Zodiac." Also to many passages in his notes to E. Burgess's translation of the *Sūrya Siddhānta*, especially I., 27-34, p. 14.

Calendar, the day universally recognised being the civil, or *sāvana*, day, *i.e.*, the natural day measured from sunrise to sunrise. The length of this perpetually varies; and since the sun may enter a sign, or in other words since the astronomical beginning of a month may take place, at any moment of the day or night, rules were laid down, which differed in different localities, as to the civil beginnings of the month, the principle in general being that it began at that sunrise which is nearest to the saṁkrānti or astronomical beginning of the month. (*See* § 43 *below.*) Purely solar reckoning has rarely been adopted except in Bengal, and, partially, in the Tamil and Malayālam tracts of Southern India.

15. In the rest of India, the calendar is based on luni-solar reckoning, the lunar months being fitted to the natural course of the seasons by the system of intercalation and suppression; in other terms a luni-solar reckoning was established—and that from a remote period. It is not necessary here to enter into a dissertation regarding the varying practices adopted, and it need only be mentioned that the general practice now makes the luni-solar year begin at sunrise of the day that immediately follows the moment of that new-moon which takes place next after the moment of the astronomical beginning of the last month of the sidereal solar year, *i.e.*, after the moment of Mīna saṁkrānti in each year. This necessitates constant calculations. Since there are 365 or 366 days in the twelve solar months and only 354 days in the twelve lunar months, the luni-solar year is fitted to the sidereal solar year by a series of clear but rather complicated rules. These are fully explained in their place. The result is that the luni-solar year contains sometimes twelve and sometimes thirteen lunar months; and that it comprises a varying number of civil days, viz., either 354, 355, 383, 384 or 385 such days. In some tracts at the present time, and in more ancient days generally, the luni-solar year begins, not with the new-moon succeeding the Mīna saṁkrānti, but with the moon succeeding one of the other solar saṁkrāntis; or indeed with some tithi (*see para.* 18) not the first of the lunar month. For such variations it suffices to refer readers to § 52, pp. 31, 32, of the *Indian Calendar.*

The term "luni-solar."

15A. I have been urged to abandon altogether the term "luni-solar" year and substitute "lunar," on the ground that while there is a luni-solar *cycle* there is no such thing as a really luni-solar *year*. I shall not contest the point, or attempt to justify my use of the term except from one standpoint. This volume is a continuation of the *Indian Calendar*, and in that volume we used the expression "solar year" to mean the duration of the twelve sidereal solar months; "lunar year" to mean the duration of twelve lunar months, each being one synodical revolution of the moon; and "luni-solar year" to mean the lunar year as adapted to the solar year and beginning, in the amānta system, with the new-moon succeeding the solar Mīna saṁkranti of each year. Such a year, containing as it does sometimes twelve, sometimes thirteen lunar months, having been called the "luni-solar year" in the *Indian Calendar*, it would tend to create confusion if I were now to make a change and give it another name. Even if scientifically inaccurate the name must stand in respect of the present publication.

16. The sun's apparent (or true) and mean longitudes are measured, as stated above, from the sidereal fixed First Point of Mēsha. His *apparent* longitude is his real angular distance at any moment from that point, measured in the direction of his course. His mean longitude is this angular distance as it would be supposing he moved with a mean or average rate of motion, or with a velocity that never varied. At the moment when the apparent sun reaches longitude 0°, *i.e.*, at the moment of apparent Mēsha saṁkrānti, the mean sun is some distance away. The true sun has travelled quicker than the mean sun, and the mean sun does not reach longitude 0° till after a period variously calculated by the various Hindū authorities, but always consisting of something over two days. This period we have called the "śōdhya" interval. (*See* § 39*A below, &c.*) An apparent *nirayana*, or sidereal, saṁkrānti takes place when, measured by his apparent motion, the sun touches the first point of each fixed sidereal sign (*rāśi*); a mean *nirayana* or sidereal saṁkrānti takes place when the sun, measured by his mean

motion, touches the first point of each fixed sidereal sign; a tropical (*sāyana*) saṁkrānti takes place when the sun touches the first point of any one of the tropical signs, which signs are, like the others, at intervals of exactly 30° from one another, but the first point of the first of which exactly coincides with the vernal equinox as calculated for the year. That is to say, in this last case the sun's longitude is calculated not from the sidereal fixed point, but from the vernal equinoctial point, the precession of the equinoxes being taken into account.

17. Though it is highly improbable that any Hindū pañchāṅg, or almanack for the year, was ever based on the tropical saṁkrāntis, it is possible that these were sometimes taken into account and were ascertained and stated as amongst the year's phenomena. Therefore, for computation of Hindū dates we have to calculate generally the moment of occurrence of apparent saṁkrāntis; sometimes, especially in earlier years, the mean saṁkrānti; and occasionally the tropical saṁkrānti. It is possible that the last might be calculated either by the sun's apparent or mean motion, but I think it unlikely that the Hindūs would have used mean motion for calculating a tropical saṁkrānti, and such a process will not, therefore, be considered in this volume.

18. A purely lunar year, such as that of the Muhammadans, takes no account of the sun's place in the heavens, but, as explained above, the Hindū luni-solar year does so, each such year beginning with the new-moon next following the time of one of the solar saṁkrāntis. The difference between the lengths of the lunar year and the solar year necessitates the intercalation of a lunar month roughly every three years and the suppression of one at intervals ranging from nineteen years upwards.[1] This subject is fully considered in its place. Each lunation, or lunar month—new-moon to new-moon (the amānta system) or full-moon to full-moon (the pūrṇimānta system)—is divided into two pakshas or fortnights, and thirty tithis, fifteen to each fortnight, a tithi being the time occupied by the moon in travelling 12° from the sun. (§ 7, *p.* 3, *Ind. Cal.*) The tithi therefore may begin at any moment, day or night, of a solar day; but as a general rule a civil day is coupled in Hindū calendars with the name of the tithi current at sunrise. Our Tables are prepared so as to establish this concurrence for mean, and not true, sunrise, since the latter varies with the latitude and longitude of each place. To prove a date we have to ascertain the tithi current at sunrise of a certain civil day, or at any given moment of such a day, in any year; that is to say, we have to establish the position of the moon at that moment.

19. It is practically more convenient, especially for the examination of records bearing date within the last few centuries, to work by the amānta system and by true, not mean, tithis, and the *Indian Calendar* Tables are founded on this principle. According to it a lunar month begins at the moment of new-moon, or at the moment when the longitudes of the true sun and the true moon are equal. The first tithi ends and the second begins when the moon has increased her distance from the sun by exactly 12°, and so with the rest. Hence to find the mean time of beginning and ending of any given tithi we have to find first the mean longitudinal distance of the moon from the sun, and then to correct this to its true longitudinal distance by applying to it the equation of the centre for the moon and for the sun.

19A. This may be accomplished in several ways, but the way we adopted in the *Indian Calendar* was to work by what we may call the "*a, b, c* system," following Professor Jacobi in his Tables in the *Indian Antiquary*, Vol. XVII. (*q.v.*, especially for present purposes, *Part* II., *pp.* 147–48). This system must now be explained. As before stated, both the sun and moon are in Hindū astronomy considered to be planets. Now a planet's true angular distance from the perihelion, or in the case of the moon from the perigee, point of its orbit is called its "true anomaly." Its "mean anomaly" is what that angular distance would have been if the planet had moved with mean or unvarying velocity. The difference between the true and mean anomalies, or the quantity necessary to make the mean equal to the true anomaly, is called the equation of the centre. (*See Ind. Cal.*, § 107, *p.* 60.) Therefore, to find the

[1] *Ind. Cal.*, § 50A

true angular distance of the moon from the sun at any moment, or the distance which proves what true tithi was current at that moment, we have to find, first, the angular distance of the moon from the sun in mean longitude (this is the "*a*" of our Tables), then the moon's mean anomaly (our "*b*"), and the sun's mean anomaly (our "*c*"), and then to apply to the *a* so found the equations of the centre of the moon and the sun, viz., our "equation *b*" and "equation *c*." We then have the true angular distance of the moon from the sun, namely our *t*, or tithi-index, and can decide correctly by the help of Table VIII. (*Ind. Cal.*) which tithi was current at the given moment.

20. The following is the method adopted for stating the quantities expressed by *a*, *b*, *c*, respectively: *a* is stated in 10,000ths of a circle, so that the unit when measured in time varies constantly with the length of the lunation, the average time for each unit being about 4.25 minutes. *b* and *c* are stated in 1000ths of the circle. Now, in the case of both the moon and the sun the equations of the centre are necessarily sometimes minus and sometimes plus. Thus, when the moon is on her perigee point the mean anomaly is 0. She is then moving rapidly, and during the period covered by her in travelling to a distance of 90° from the perigee point the difference between her mean and true longitudes constantly increases, the true gaining on the mean; or in other words, equation *b*, applied to bring the mean up to the true, is a quantity *plus*, which becomes constantly larger. From 90° to 180° equation *b* decreases, till at the apogee point it is again 0, the mean and true anomalies being then at one. From 180° to 270° the mean gains on the true, the moon's true motion being slow, so that equation *b* is here a constantly increasing *minus* quantity. From 270° back to perigee point the equation is still minus, but in ever lessening degree, till at perigee it is again 0. And the same with the sun. The greatest possible equation *b* (moon) is, in terms of *a*, 140.2, sometimes minus and sometimes plus; and the greatest possible equation *c* (sun) is 60.4. In order that these equations may be always additive when applied to *a*, the sum of 140.2 is, in our Tables VI., VII., added invariably to equation *b*, and 60.4 to equation *c*; the total 200.6 being in compensation deducted from every value of *a*. Thus in Table VI. when the true value of equation *b* is 0 we have tabulated 140; when its true value is 140.2 we have tabulated 280, and so on; and similarly with equation *c*. Thus, opposite argument 0 is tabulated 60, for 60.4, instead of 0; and opposite argument 750 is tabulated 121 for 120.8 instead of 60.4. Every calculation is then additive. When, therefore, we have, working by the *mean* system, found the value of *a* in the work of testing the date of an inscription we must add 200.6, or 201, to *a* in order to arrive at the *real mean* longitudinal difference between the moon and the sun. The value of *a* when we calculate by mean months and the value of *t* when we calculate by true months, or the tithi-index resulting from such calculation in either case, is converted into tithis and decimals by use of Table VIII.B, cols. 1, 2, or by multiplying *a* or *t* by 3 and marking off three places of decimals; and is converted with fair accuracy into degrees and minutes by col. 3 of that Table. But employment of this last process is not recommended as, if degrees and minutes are wanted, it would be safer to make the calculation by Professor Jacobi's "Special Tables." (*Epig. Ind., Vol. I.*)

21. That one point may be thoroughly understood I think it well to repeat what has already been stated. The addition of 200.6 or 201 has only to be added to the resulting *a* in calculations for mean intercalations or suppressions of lunar months, or for mean lunar months and tithis, and not to the resulting *t* in calculations for true intercalations and suppressions, or for true lunar months and tithis; since in the latter case the addition of equations *b* and *c* to the value of *a* cancels the arrangement, made for convenience, whereby the maximum value of those equations was deducted from *a* and added to their values in the Tables.

a and *t* being stated in 10,000ths of a circle, a result which shows that $a + 201$ (in calculations by mean longitude) or *t* (in calculations by true longitude) = (say) 1 or 9823, means that the moon's distance from the sun is, in terms of *a* or *t*, 0.0001 or 0.9823. (*See Ind. Cal.*, §§ 102, 107, 108, *pp.* 56, 60, 61.)

22. Another point requiring notice concerns the time-duration of the tithi. Having found by the above process the value of t or the tithi-index for the given moment, we may require to ascertain the times of the beginning and ending of the tithi in question. Its beginning and ending values are given in Table VIII., col. 3, and by subtracting the found value of t from the ending value of the tithi we find how many lunation-parts intervened between the time for which we have worked and the ending-point of the tithi. We convert these intervening lunation-parts into mean time by the use of Table X. (heading "Tithi-Index"). And we similarly find the mean time of the beginning of the tithi by subtracting the value given in Table VIII., col. 3, for the beginning from the found value of t, and converting the difference into mean time as above. Say that we find that at sunrise on a certain civil day $t = 2362$. By Table VIII., col. 3, we find that the 8th tithi śukla, or the 8th tithi of the first fortnight, was current. It began $(2362 - 2333 =)$ 29 lunation-parts = (Table X.) 2 h. 3 m. (mean time) before sunrise. It ended $(2667 - 2362 =)$ 305 lunation-parts = (Table X.) 21 h. 16 m. + 21 m. = 21 h. 37 m. (mean time) after sunrise.

23. But Table X. shows only the values of the mean tithi, under both the headings "Tithi-parts" and "Tithi-index"; and as every true tithi varies in time-length because of the varying velocity of the true moon in its orbit, it is incumbent on us, if we desire absolute accuracy, to work the case to a conclusion as explained in the *Indian Calendar* (§ 82, *p.* 50, *and pp.* 81, 82.) Having done this we get the final and correct beginning and ending times of the true tithi.

24. In the examples given below, the figures given under head d (generally given in brackets, as in Table I., cols. 13, 19 of the *Indian Calendar*) refer to Table IX. of that work, from which the European month and day of the month are obtained. In the numbers given for (w) days of the week, 0 is Saturday, 1 Sunday, &c.

25. In adding together the necessary figures for a or t all values over 10,000 are taken less 10,000, and in figures for b and c all values over 1000 are taken less 1000; since the figures represent longitude measured by 10,000ths and 1000ths of a circle, and when a full circle has been described and the point 0 is reached a new circle of course commences.

26. In actual work we often find that our result differs by one unit in a or b or c from the expected result, and it is well to remember that this difference is inherent in the system. Each unit in a, for instance, represents a time-interval of about 4.25 m., and we advance by whole units; but such advance, with decimals or fractions ignored, often causes a difference in the ultimate figure. An example of this can be gathered from Table IV. If I desire to state the a for 395 days I can either do it by adding the a of 385 days to the a of 10 days, or by adding the a of 300 days to the a of 95 days. In the former case the result is $(373 + 3386 =)$ 3759; in the latter it is $(1590 + 2170 =)$ 3760. See also the case stated under "Correction III." below (*para.* 57). Here we have two figures stated with decimals which have to be added together. One is 200.6 and another is 7.83. Stated separately these would be stated in whole figures as 201 and 8. Total, as so stated, 209. But added with the decimals the total is 208.43, which, stated as a whole figure, would be 208. Such differences are practically unavoidable in every working system.

SOLAR RECKONING.

Samkrāntis.

27. The twelve sidereal saṁkrāntis occur at the beginning-points of the twelve signs of the zodiac, separated from one another by 30° of celestial longitude. The first, called the Mēsha saṁkrānti,

occurs when, in his path on the ecliptic, the sun's centre is at longitude 0°, or precisely on the sidereal fixed starting point—the first point of the first sign Mēsha; the second takes place after the sun has travelled 30°, and so on for the twelve. Their names will be found in col. 5*a*, Table III., of the *Indian Calendar*; the duration of each sign and its correspondence with the nakshatras (*below*, § 112, *etc.*) are given in Table XXII.[1] The time required for the sun to pass completely from one saṁkrānti to another, or the time during which it remains in one sign, constitutes a *saura māsa* or solar month. Each saṁkrānti bears the name of the sign whose beginning it marks. The Mēsha saṁkrānti is the beginning point of the solar month Mēsha, and so for all.[2]

28. Since the sun travels the uniform distance between saṁkrāntis at varying speed throughout the year, the length of every month, when considered in the light of the sun's true or apparent motion, differs from every other. Both the *Ārya* and *Sūrya Siddhāntas* fix the mean length of a solar month, *i.e.*, the month's length as it would be if the sun moved with a velocity that never varied, at 30 d. 10 h. 31 m., the former adding 2½ s. and the latter 3.05 s. The lengths of the true months by each are given in Tables XVIII.A and XVIII.B below. The definition of apparent, mean, and tropical saṁkrāntis has been given above. Whenever mention is made of a "saṁkrānti" in the present treatise or in the *Indian Calendar* a true sidereal, or nirayaṇa, saṁkrānti is meant, unless the name is specially otherwise qualified.

29. A saṁkrānti therefore marks, whatever calculation may be adopted, the astronomical beginning point in time of a solar month. This may take place at any moment of a day. The civil beginnings according to local practice are considered below. ("*Days of a Civil Month*," § 43.) These civil days begin at sunrise, and sunrise is generally taken (always in our Tables) as mean sunrise; but since it is probable that the beginning of the day was always true sunrise, the difference between the two must often be taken into account. This difference depends on the longitude and latitude of the place, not necessarily of the actual place of the inscription, but, as is now well understood, probably the longitude and latitude of the principal centre of life in the neighbourhood, where the almanacks were constructed. It depends also on the equation of time. (*See* §§ 34–36, *pp.* 17–20, *Ind. Cal.*). The most accurate and complete treatise on this subject is by Professor Jacobi in the *Epigraphia Indica* (*Vol. II., pp.* 487–498.) A Table for applying the equation of time, for converting, that is, mean to apparent time from A.D. 200, is given in Table F. of my *Eclipses of the Moon*, while Table G. of the same work gives the apparent time of the sun's rising and setting for various latitudes.

30. The time of occurrence of a saṁkrānti, and hence the civil beginning of a solar month, is found by adding the collective duration of the months preceding it (*Tables XVIII., XIX., below*) to the time of occurrence of the Mēsha saṁkrānti of the year (*Table I.*). By the true system the duration of true months must be added to the moment of true Mēsha saṁkrānti. By the mean system the duration of mean months must be added to the moment of mean Mēsha saṁkrānti. (*Below*, "*Correction III*," § 57.)

The moment of true Mēsha saṁkrānti in all years from A.D. 300 to 1900 is given in Table I. of the *Indian Calendar*, according to the *Ārya Siddhānta* throughout and according to the *Sūrya Siddhānta* after A.D. 1100; also, for the *Ārya Siddhānta*, from 58 B.C. to A.D. 299, in Table XXXVIII.A. below. Rules for finding the same by the *Original Sūrya Siddhānta* will be found in § 162 below, and by the *Brāhma Siddhānta* and *Siddhānta Śirōmaṇi* in § 167A. (*See also* §§ 47 *to* 54.)

31. The Vishuva saṁkrāntis are the two equinoctial ones, Mēsha and Tulā. The solstitial saṁkrāntis are the Uttarāyaṇa (winter-solstice) and Dakshiṇāyana (summer-solstice) saṁkrāntis.

The Mithuna, Kanyā, Dhanus and Mīna saṁkrāntis are sometimes called the Shaḍaśītimukha saṁkrāntis. (*Ind. Ant. XXV.*, 346, *No.* 4.)

[1] See also §§ 23, 26, pp. 9, 11, *Indian Calendar*.

[2] For the other names of the solar months, ancient and modern, see *Indian Calendar*, p. 10, and Table II., Part II., cols. 8 to 13.

Calculation by Mean Motion.

32. In ancient days astronomers and astrologers seem to have generally, if not invariably, calculated by the mean motions of the sun and moon, partly no doubt because such calculation was easier than the other; but we have as yet no means of knowing for certain to how late a date or in what parts of India mean calculations continued to be made in spite of the practice, growing in favour from the beginning of the tenth century A.D. (*Kielhorn: Note* 1, *p.* 813, *Journal of the R. Asiatic Soc. for* 1896), advocated by Śrīpati (A.D. 1040) and established all over India not long after his date, of measuring by the true motions. (*Ind. Cal.*, *p.* 28). Nor do we know for how long previous to the tenth century, if at all, the "true" system had been adopted in some places. We have therefore to be careful in examining the dates of inscriptions from about A.D. 850 to 1150, and not to reject at once as irregular a date which at first appears to be so. It should be tested by both systems before rejection.

For this reason I have prepared Tables XVIII.A, XVIII.B, XVIII.C, and XIX.A, XIX.B in order to facilitate the conversion of results found by the true system into results according to the mean system and *vice versa;* and also to enable results found by use of the *Ārya Siddhānta* to be turned into the same by the *Sūrya Siddhānta* and the contrary. Their use is explained below.

Tropical Saṁkrāntis.

33. As above explained the tropical or sāyana, "with movement," Mēsha saṁkrānti takes place at the moment when, *the precession of the equinoxes being taken into account*, the sun's centre in his path on the ecliptic cuts the equator *at the vernal equinox*. According to some Hindū authorities the point of the vernal equinox shifts annually from its place in the previous year, always in one direction, till it has reached a point 27° from the sidereal First Point of Mēsha, after which it shifts backwards and proceeds to a point 27° on the other side of the fixed sidereal point, when it again reverts. On this theory of libration the First Point of Mēsha is always the mean place of the equinoctial point, though separated by an immense number of years from the furthest equinoctial point. The longitude of the sun at every tropical saṁkrānti is measured from the equinoctial point. Each tropical saṁkrānti occurs when the sun has travelled 30° from the last, and there are twelve saṁkrāntis in the tropical year. We have to be prepared for an inscription-date having been calculated by tropical saṁkrāntis, though I imagine such a case to be very rare. What is more probable is that occasionally, a clever almanack-maker having discovered that a date happened to coincide with the occurrence of a tropical saṁkrānti, the fact was mentioned in the Pañchāng, and embodied in a recorded date; but it is extremely unlikely that such calculations could ever have been regularly used as a basis on which to build up the details entered in an ordinary almanack. Such a mode of calculation would necessitate an annual revision by some central authority of the time-lengths or duration of the different solar months; since it stands to reason that the time taken by the sun to travel, for instance, the 30° from the fixed initial Mēsha saṁkrānti-point to the next, Vṛishabha, saṁkrānti-point is not the same as the time taken by him to travel 30° from the equinoctial point, except in the one case of those two initial points being exactly in coincidence; and as the equinoctial point shifts annually in its relation to the sidereal starting point, so the lengths of the several solar months would have to be annually altered if Hindū almanacks were to be regularly prepared in accordance with a tropical system. There can be no doubt that in India almanacks were prepared according to the standard system laid down by one or other of the ruling authorities, namely, in one or other of the *Siddhāntas;* and in these the precession of the equinoxes was only considered incidentally.[1]

[1] The Hindū year is believed to have been sidereal for at least 2000 years. (Sh. B. D. in *Indian Calendar*, § 17, pp. 6, 7

34. Nevertheless, since tropical saṁkrāntis may occasionally be met with in inscriptions, we have to lay down rules for calculating them. And the first question to be decided is in what year the sidereal and tropical Mēsha saṁkrānti-points coincided. According to the *Present Sūrya Siddhānta* they were together in Śaka 422 current, K.Y. 3601 current, or A.D. 499, the rate at which the equinoctial point shifts annually being 54″. By almost all the other authorities the coincidence took place in Śaka 445 current, K.Y. 3624 current, or A.D. 522, the rate of annual precession being one minute (1′). The *Siddhānta Śirōmaṇi* places the coincidence in Śaka 450 current, K.Y. 3629 current, or A.D. 527, also with precession at 1′.[1] The translators and annotators of the *Sūrya Siddhānta* more than once assert (*Burgess's Sūrya Siddhānta, p.* 14, *&c.*) that by its precession-rate the coincidence must have been in about A.D. 570; but with reference to viii., 9, after a careful calculation and examination connected with the position of the junction-stars of the nakshatras, resulting in proof of an average error of longitude, they write (op. cit. p. 211), that this "would indicate that the Hindū measurements of position were made from a vernal equinox situated about 1° to the eastward of that of A.D. 560, and so at a time seventy years previous to the date we have assumed for them, or about A.D. 490." And if for "560" we read "570" we should arrive at the year A.D. 500. I assume therefore the correctness of the *Indian Calendar* in this respect.

On this matter Dr. Fleet gives me the following remarks. It is only by backward calculation that such-and-such years are fixed as the times when, according to different authorities, the degrees of precession were nil: there is no record coming down from those times themselves. Albērūnī suggests (*trans. Sachau*, 1, 366) that the Hindūs became aware of precession, or at any rate began to pay attention to it, only about A.D. 989. And this is practically borne out by the facts, as far as we can trace them. Āryabhaṭa (who wrote in, or soon after, A.D. 499) and his exponent Lalla do not mention precession at all. Varāhamihira (died A.D. 587) mentions an effect of it; namely, a shifting of the solstitial points from ancient positions assigned to them by the Jyōtisha-Vēdāṅga to the positions which they had in his own time: but he does not disclose any knowledge of the cause of the shifting. Brahmagupta (wrote A.D. 628) mentions precession in a somewhat vague manner, but only does so to deny it. And as far as our knowledge goes at present, it was first taught by Muñjāla, who wrote in A.D. 932.

35. Whichever authority is selected, the difference in years between its year of coincidence, or base year, and the given year, multiplied by the annual amount of precession, will show the longitudinal distance in degrees by which in the given year the tropical, or sāyana saṁkrānti precedes or follows the sidereal, or nirayaṇa saṁkrānti. The former precedes the latter in all years later than the selected base-year of coincidence, and follows it in all earlier years. In years earlier than about A.D. 1100 it will be well to take K.Y. 3623, A.D. 522–23, or the year of coincidence according to the *Ārya Siddhānta*, as the base-year, with an unit of precession of 1′; but after about A.D. 1100 calculation may be made by both the base-years K.Y. 3600, A.D. 499–500, and K.Y. 3623, A.D. 522–23, since both the *Ārya* and *Sūrya Siddhāntas* have been in constant use ever since as authorities in different parts of India; the former especially in the Tamil and Malayāḷam countries of South India where the solar reckoning is largely followed.

36. The rules for finding the moment of a tropical saṁkrānti are given on pp. 152-53 of the *Indian Calendar*, "Additions and Corrections." But to save trouble of reference they are here repeated with fuller explanation. First find the time of the nirayaṇa true Mēsha saṁkrānti by the authority used. (*See Table I., cols.* 14 *to* 17 *and* 14*a to* 17*a*, *Ind. Cal., and Examples* 3, 4 *below.*) Add the collective duration given in Table XVIII.A or XVIII.B, cols. 3, 4, by the same authority from this nirayaṇa Mēsha saṁkrānti to the true nirayaṇa saṁkrānti in question. The total gives the time of the required nirayaṇa saṁkrānti. For a rough guide, the sāyana saṁkrānti took place as

Rule for finding moment of a tropical saṁkrānti.

[1] I accept in the matter of these dates the considered assertion of Pandit Shankar Balkrishna Dikshit, referring those interested to the discussion of the subject by Prof. Whitney, "The Lunar Zodiac," in *Oriental and Linguistic Studies* (1874). Whitney inclines, so far as the *Sūrya Siddhānta* is concerned, to the year A.D. 490 (p. 379), though with doubt.

many ghaṭikās[1] before or after the nirayaṇa one as there are years between (for *Ārya Siddhānta* calculation) K.Y. 3624 current, or (for *Sūrya Siddhānta* calculation) between K.Y. 3601 current and the year next following or next preceding the given year. This rough calculation involves an error which, beginning at the base-year, increases yearly to as much as one day by about the year A.D. 1900. It amounts to about 1 m. 1.7 s. per annum, or about one hour every $58\frac{1}{3}$ years, and it is partly caused by the fact that the estimate of the sun's motion as 1 ghaṭikā in 1′ of longitude is only an approximation.

37. For more accurate purposes the following is the process. Having found the number of years intervening between (*Ārya*) K.Y. 3624 current, or (*Sūrya*) K.Y. 3601 current, and the given year, multiply that number by, in the case of the *Ārya* $\frac{1}{60}$, or, in the case of the *Sūrya*, by $\frac{3}{200}$. Take the product as the amount of precession in degrees accumulated by the beginning of the given year since, or prior to, the coincidence which has been assumed to have occurred in the base-year. These degrees of precession are called ayanāṁśas. The product gives the longitudinal distance of each equinoctial saṁkrānti point from the corresponding sidereal (nirayaṇa) saṁkrānti point. With this knowledge we proceed to find the difference in time between the sun's arrival at those two points, or the interval between them in days. Those days, in years succeeding the base-year of coincidence, belong sidereally to the month preceding the saṁkrānti with which we are concerned; though in years prior to the base-year, they belong sidereally to the same month. Thus, if we are working for a tropical Kanyā saṁkrānti, the interval of days between tropical Kanyā and sidereal Kanyā belong to sidereal Siṁha in years following the base-year; but in years prior to the base-year they belong to sidereal Kanyā. We know the lengths of those apparent months by Table XVIII.A or XVIII.B, according to the Siddhānta by which we are calculating; and we have only to multiply the time occupied by the sun in travelling 1° during such a month by the amount of the intervening ayanāṁśas to obtain in days the required difference in time between the sun's arrival at the sidereal or tropical saṁkrānti-point concerned. The rule therefore is: Multiply the exact length of that month by the amount of ayanāṁśas found, and, dividing by 30, take the product as days; and by so many days, hours and minutes will the sāyana saṁkrānti precede or follow the moment of the nirayaṇa saṁkrānti according as the given year is after or before the base-year.

38. A little further explanation is still necessary. In finding the ayanāṁśas for the given year by the *Ārya Siddhānta* the number of intervening years is divided by $\frac{1}{60}$ because the numerator 1 represents 1°, and $\frac{1^\circ}{60} = 1'$, which is the amount of annual precession assumed for that authority. In the case of the *Sūrya Siddhānta* the fraction $\frac{3}{200}$ represents $\frac{3^\circ}{200} = \frac{9'}{10} = 54''$, which is its amount of precession per annum. The error inherent in this more accurate method of calculation is estimated by Sh. B. Dikshit as amounting to only about 1 hour in every 240 years.

39. To simplify the second rather complicated process of multiplication I have prepared Tables XX.A and XX.B. Table XX.A shows in time and in decimals of a day the time occupied by the sun in travelling 1° during each sidereal month, according to either the *Ārya* or the *Sūrya Siddhānta*; and Table XX.B shows in degrees and in decimals of a degree the amount of ayanāṁśas we require when using the *Sūrya Siddhānta*, those required when using the *Ārya Siddhānta* being too easy to require a Table.

Thus, referring to Examples 9 and 10, instead of the rather troublesome process of calculating $\frac{30\text{ d. }8\text{ h. }7\text{ m. }42\text{ s.} \times 9\frac{1}{4}^\circ}{30}$ in Example 9, or the still more intricate $\frac{30\text{ d. }8\text{ h. }29\text{ m. }1\text{ s.} \times 8^\circ\,40'\,12''}{30}$ in Example 10, we may, using Table XX.A, take the former sum as 1.0113 × 9.25, and the latter as 1.0118 × 8.67.[2]

[1] Precession per annum being 1′ (*Ārya*), or 54″, *i.e.*, nearly 1′ (*Sūrya*), and the earth's motion being about 1° per day, or 1′ in a ghaṭikā approximately.

[2] In Example 10 the difference of years was found to be 578, and col. 5 of Table XX.B gives us for 500 years 7° 5′, for 70 years 1° .05′, and for 8 years 0° 12′, total 8.67° in ayanāṁśas; or the same amount may be gathered for A.D. 1077 from cols. 2, 3, viz., for A.D. 1000, 7.515°, and for 77 odd years 1.05° + 0.105°, total 8.67°

This gives us for the former (Ex. 9, *Ārya Siddhānta*) 9.354525, which, when taken as days (Table XXXVI.) = 9 d. 8 h. 30 m. 31 s.; and for the latter (Ex. 10, *Sūrya Siddhānta*) 8.772306, which, when taken as days = 8 d. 18 h. 32 m. 7 s. Both these results are almost similar to those given by the more complicated process in the two examples quoted. If fully worked the results exactly agree.

The Śōdhya

39A. In very accurate calculations for tropical saṁkrāntis the annual change in the position of the line of apsides of the earth's orbit ought strictly to be taken into account, and the consequent slight change in the śōdhya interval, or the time difference between the moments of true and mean Mēsha saṁkrānti; though even in the 5000 years embraced by our Tables the change in the śōdhya has been exceedingly small.

39B. Since, however, the amount of this difference as it existed in K.Y. 1 current or the epoch of the Kaliyuga is of very great importance later on when we come to deal with the saṁvatsaras of Jupiter, it will be well that I should here, once for all, consider the subject in detail. The word "*śōdhya*" means in mathematics something to be subtracted or cleared off with the view of rectifying a stated quantity; but, following the *Indian Calendar*, I apply the name to the time-difference between the mean and true sun (or the sun's place as measured by his mean and his true longitude) at the first point of Mēsha, or longitude 0°, the point from which all celestial longitudes are measured in Hindū astronomy. It represents the time-equivalent of the equation of the centre, or the difference between the time at which the sun, moving with his true velocity in the ecliptic, reaches the first point of Mēsha and the time at which he would reach it if his velocity were constant. Both true and mean suns are together on the perigee and apogee points of the orbit, but by the time the true sun, having left the perigee point, reaches longitude 0° or 360° the mean sun is behind it. The difference between them is the śōdhya. Exactly 180° from the perigee point is the apogee point, and a line joining them is the "line of apsides." Now there is a slight annual shift in this line of apsides, and consequently a slight change in the longitude of the apogee and the perigee. Since the velocity of the true sun, and therefore the time at which it reaches longitude 0°, depends on the position of the line of apsides, it follows that, in proportion to the shift of that line or the change in the longitude of the apogee point, there must be a change in the śōdhya interval. But this change is exceedingly slow. According to the *Sūrya Siddhānta* the annual change in the position of the sun's apogee is only 0.1161",[1] while the *Ārya Siddhānta* does not teach any change at all; and since by the *Sūrya Siddhānta* the difference of anomaly (*Ind. Cal., p.* 5, *note* 4) in 5000 years only amounts to 9′ 13″, it is evident that the difference in the śōdhya in years divided even by so long a period would amount to very little. I have therefore retained for the initial point of Kaliyuga reckoning (otherwise called the "epoch of the Kaliyuga," or mean Mēsha saṁkrānti of K.Y. 0 expired or 1 current) the śōdhya value as calculated for K.Y. 4238, or A.D. 1137 (*see Ind. Cal.*, §§ 24, 26, *p.* 11), *i.e.*, its value for longitude of apogee 77° 16′. It amounts by the *Sūrya Siddhānta* to 2.170694 days, and by the *First Ārya Siddhānta* to 2.1475694 days. I admit that the time results of my Tables for Jupiter by the *Sūrya Siddhānta* may be wrong by a minute or two in consequence of my making no change in the śōdhya value for these Siddhāntas; and if the beginning of a saṁvatsara should be found to occur within a minute or two of Mēsha saṁkrānti the case may be specially examined. The value for the sun's anomaly for different centuries is given in Jacobi's (*Epig. Ind., Vol. I.*) Table XIII., and the corresponding equation of the centre in his Table XXIV. For the *Original Sūrya Siddhānta* I have taken the śōdhya value as declared by Sh. B. Dikshit in *Ind. Ant.* 1890, *p.* 49, viz. 2.23972 d., or 2 d. 5 h. 45 m. 12 s. For the rest I have accepted Dr. Schram's valuation.

[1] The authors of E. Burgess's *Sūrya Siddhānta* stated the longitude of the apogee in K.Y. 1 current as 77° 7′ 48″, and over 4200 years later it has been calculated by the same authority as 77° 16′. Prof. Jacobi states the annual change by the *Second Ārya Siddhānta* as 0.1383″, and by the *Brāhma Siddhānta* as 0.144″. (*Epig. Ind.*, I., 441.)

39C. Dr. Schram has been so kind as to carry through a series of most careful and elaborate calculations with a view to ascertaining definitely, by the elements of several different Hindū Siddhāntas, the exact value of this śōdhya interval at the epoch of the Kaliyuga and for five subsequent milleniums. Dr. Schram's results differ slightly from the results indicated in the *Indian Calendar*, which were based on Mr. Sh. B. Dikshit's fixture of valuations; and though attempts have been made to ascertain the basis for these last, none have been successful. My own endeavours were in accord with those of Dr. J. Burgess and Dr. Fleet, both of whom were good enough to help me in this respect. We can none of us find out how Mr. Dikshit arrived at his figure, 2.170694 d. according to the *Sūrya Siddhānta*, for a position of the sun's apogee taken as 77° 16′ in A.D. 1137. (*Ind. Cal.*, § 24.) Dr. Schram calculates the same as, correctly, 2.169751 d., a difference of 0.000943 d., or about 1 m. 18 s. In these circumstances the question which I had to decide was whether I should alter my figures in Tables XXVII., XXVIII., XXIX.—figures which depend on the value of the śōdhya—or leave them based on this value as settled by Mr. Dikshit. I have finally decided on the latter course for three reasons. First, the differences are not great, and I have added a note on them to each Table. Secondly, even though Hindū computation may not have been scientifically perfect, it is safer, when examining Hindū dates, to accept that computation. Thirdly, I find on practical test that results by my *Sūrya Siddhānta* Tables as they stand, with the Hindū computation of the śōdhya accepted, are very closely in agreement with the results arrived at when these are calculated by the elaborate and cumbrous formulæ laid down by the Siddhānta itself, closer than would be the case if I accepted Dr. Schram's śōdhya-valuation. (*See Example* 50.)[1] It may also be noted in this connection that the śōdhya value, when used for such purposes as for my Tables for the Jovian saṁvatsaras, is a constant quantity, and not liable to any increase, however great may be the interval from K.Y. 1 current to the given K.Y. year; so that the difference between the results is always the same, and this being small, only one or two minutes, it is not as a rule very important.

39D. Dr. Schram has sent me his full process of work by two different methods in order to arrive at the proper scientific value of the śōdhya in different millenniums (but for purposes of Tables XXVII. to XXXI., especially required for K.Y. 1 current, or 3102 B.C.). And, first, I give his results in tabular form, as follows:—

Dr. Schram's valuation of the śōdhya in days and decimals.

Year.	*First Ārya Siddhānta.*		*Sūrya Siddhānta.*	
	By a series of approximations.	By direct calculation.	By a series of approximations.	By direct calculation.
K.Y. 0	2·146831	2·146831	2·168900	2·1688997
„ 1000			2·169101	2·1691004
„ 2000			2·169302	2·1693011
„ 3000			2·169502	2·1695018
„ 4000			2·169703	2·1697024
„ 5000			2·169904	2·1699031

[1] Table XXXI., for the *Brāhma Siddhānta* and *Siddhānta Śirōmaṇi* is based on Dr. Schram's valuation of the śōdhya in K.Y. 1, current

Year.	Brāhma Siddhānta.		Siddhānta Śirōmaṇi.	
	By a series of approximations.	By direct calculation.	By a series of approximations.	By direct calculation.
K.Y. 0	2·171973	2·171971	2·171973	2·171971
„ 1000	2·172227	2·172226	2·173821	2·173819
„ 2000	2·172482	2·172481	2·175669	2·175668
„ 3000	2·172736	2·172736	2·177517	2·177516
„ 4000	2·172991	2·172991	2·179365	2·179364
„ 5000	2·173245	2·173246	2·181213	2·181213

Year.	Second Ārya Siddhānta.		Original Sūrya Siddhānta.
	By a series of approximations.	By direct calculation.	No calculation attempted owing to insufficient data.
K.Y. 0	2·171973	2·171972	Sh. B. Dikshit's valuation for K.Y. 0, viz., 2.23972, stands. (*Indian Antiquary, Vol. XIX., for* 1890, *p.* 49).
„ 1000	2·172218	2·172217	
„ 2000	2·172462	2·172462	
„ 3000	2·172707	2·172707	
„ 4000	2·172951	2·172952	
„ 5000	2·173196	2·173197	

The difference in 5000 years in the case of the *First Ārya Siddhānta* (the *Āryabhaṭīya*) amounts to 1 m. 26 s., in that of the *Sūrya Siddhānta* to 1 m. 27 s., in that of the *Brāhma Siddhānta* to 1 m. 51s., and in that of the *Siddhānta Śirōmaṇi* to the much larger amount of 13 m. 19 s. For purposes of my Tables for Jupiter, however, this difference is immaterial since they are based on the values at K.Y. 0 alone.

39E. The following shows Dr. Schram's method of direct calculation. Let x be the sun's equation of the centre at the instant of true Mēsha saṁkrānti. As the true longitude of the sun at this instant is 0° or 360° its mean longitude will be $360°-x$. At the instant of mean Mēsha saṁkrānti the sun's mean longitude is 0° or 360°, and the difference between the mean longitude of the sun at the instants of true and mean Mēsha saṁkrānti is equal to x. Now, if the mean daily motion in longitude of the sun is called m, the sun takes $\frac{x}{m}$ days to travel over this difference x, and $\frac{x}{m}$ = the śōdhya. Hence—

(i.) The sun's equation of the centre at the instant of true Mēsha saṁkrānti = x

The sun's daily motion in mean longitude = ... m

Śōdhya in days = ... $\frac{x}{m}$

The equation of the centre has to be separately calculated for each *Siddhānta*, and we require for each the sine of the sun's anomaly, or the angle α, completing the anomaly to 360°. The anomaly of the sun is the difference between the sun's mean longitude and the mean longitude of the sun's apsis.

At the instant of true Mēsha saṁkrānti the mean longitude of the sun is $360° - x$. Let the mean longitude of the sun's apsis at this instant be called β. Then we have—

(ii.) Sun's anomaly $= 360° - x - \beta$,

$\alpha = 360° -$ sun's anomaly $= x + \beta$.

To obtain the sine of α we use the Table of Hindū Sines published in E. Burgess's "*Sūrya Siddhānta,*" p. 285, and in the "Journal of the American Oriental Society," Vol. VI., p. 197, where the sine is expressed in minutes. Since at the instant of Mēsha saṁkrānti the angle α is, according to all the Siddhāntas, contained within the limits of 78° 45′ and 82° 30′, we have—[1]

(iii.) $\sin \alpha = \sin (x + \beta) = 3372' + \frac{37}{225} (x + \beta - 78° \ 45')$.

We now calculate this for the First *Ārya Siddhānta* (the *Āryabhaṭīya*).

According to Jacobi (*Epig. Ind. I., p.* 441), the sun's equation of the centre is—

(iv.) $x = \frac{13\frac{1}{2}°}{360°} \sin \alpha = \frac{3}{80} \sin \alpha$.

Substituting in (iv.) the value of sin α from (iii.) we have—

$$x = \frac{3 \times 3372'}{80} + \frac{3 \times 37}{80 \times 225} x + \frac{3 \times 37}{80 \times 225} (\beta - 78° \ 45'),$$

and from this equation—

(v.) $x = \frac{3 \times 3372' \times 225}{(80 \times 225) - (3 \times 37)} + \frac{3 \times 37}{(80 \times 225) - (3 \times 37)} (\beta - 78° \ 45')$,

or $x = 127.23461345' + 0.0062049304' (\beta - 78° \ 45')$.

According to this *Ārya Siddhānta* there are in a yuga 4,320,000 revolutions of the sun and 1,577,917,500 civil days; and therefore the mean daily motion in minutes is—

(vi.) $m = \frac{4{,}320{,}000 \times 360 \times 60}{1{,}577{,}917{,}500}$

(vii.) and śōdhya $= \frac{x}{m} = \frac{3 \times 3372' \times 225 \times 1{,}577{,}917{,}500}{17{,}889 \times 4{,}320{,}000 \times 360 \times 60} + \frac{3 \times 37 \times 1{,}577{,}917{,}500}{17{,}889 \times 4{,}320{,}000 \times 360 \times 60} (\beta - 78° \ 45')$.

or śōdhya $= 2.15155310$ d. $+ 0.0001049261$ d. $(\beta - 78° \ 45')$.

As according to this *Ārya Siddhānta* the longitude of the sun's apsis is always 78°, we have $\beta = 78°$, or $(\beta - 78° \ 45') = -45'$.

Putting in this value respectively in (v.) and (vi.) we have always—

(viii.) Sun's equation at true Mēsha saṁkrānti $= 2° \ 6.9553916'$; and śōdhya, in days, $= 2.14683143$, or shortly, 2.146831 d.

On this principle Dr. Schram has calculated for the other Siddhāntas concerned.

39F. By his other method of approximations he took the data from the recognized authorities, *e.g.*, the sun's anomaly from Jacobi's *Epigraphia Indica* (Vol. I.) Tables, as well as the sun's mean daily motion (*ibid., p.* 442); the sun's true daily motion at the moment of Mēsha saṁkrānti from Warren's *Kala Sankalita,* Table XXVIII.; the equation of the sun's centre from Jacobi (*op. cit., p.* 441); and the sun's mean longitude for the instant when his true longitude is 0° (viz., 357° 51′ 38″) from Jacobi's Table XX. Taking this last as his first approximation for the sun's mean longitude at mean Mēsha saṁkrānti, he finds the anomaly from this mean longitude *minus* the longitude of the apsis (78°), and thence obtains the value of sin α. Having worked out three separate, and each closer, approximations, he obtained for final result the same figure as given above for the śōdhya, viz., 2.146831 d. He then proved this result by Jacobi's Table XXIV.

Dr. Schram's calculation for the *Sūrya Siddhānta* was complicated by the fact that it contains a quadratic term. The sun's equation of the centre is (*Jacobi, Epig. Ind. I.,* 441)[2] $x = \frac{14}{360} \sin \alpha - \frac{1}{3 \times 360 \times 3438} \sin^2 \alpha$. This formula being substituted in (iii.) above gives the starting point for

[1] The quoted Table of sines tabulates, for an angle of 78° 45′, 3372′, and the next angle dealt with is 82° 30′. The difference between the sine of the first and the sine of the second angle is 37′. As the difference between the angles is 225′ the difference for each minute is $\frac{37}{225}$. Therefore, if the angle to be dealt with is, as here, greater than 78° 45′—if, that is, we are dealing with an angle 78° 45′ + A — the sine of that angle is $3372' + \frac{37}{225}$A. Hence formula (iii.).

[2] There is a misprint in Prof. Jacobi's paper on p. 441, l. 18, where he gives the equation of the sun's centre for anomaly α as $= \sin \frac{32}{360} \alpha -$ &c. The whole should be $\frac{14}{360} \sin \alpha - \frac{20}{3438 \times 360 \times 60} \sin^2 \alpha$.

the calculation. It is not necessary for me to reproduce the whole process, which is elaborate and most carefully worked. The result is as I have tabulated above.

Prof. Jacobi's "Indian Antiquary" (Vol. XVII.), Tables 1-4.

40. These Tables were constructed for the purpose of enabling the initial days of solar months according to the *Ārya Siddhānta* to be approximately found at a time when no reliable lists were available; but after the publication of Table I. of the *Indian Calendar,* which fixes the time of Mēsha saṁkrānti each year in hours and minutes, and of accurate Duration-Tables of months, both true and mean, such as are given in Table III. (*Ind. Cal.*) and Tables XVIII. and XIX. below, Professor Jacobi's Tables 1–4 are no longer wanted.

41. It is advisable, however, to point out for the benefit of anyone who may desire to use them that, as admitted by the author (*Ind. Ant., XVII., p.* 147*a*), they contain an inherent source of error. This error may amount to as much as 52 minutes. Thus in his Table I., taking the 576-year cycle from A.D. 373 to 949, his results differ from the actuals by 12 minutes during the first 116 years, by 22 minutes during the next, by 32 minutes during the next, by 42 minutes during the next, and by 52 minutes in the last 112-year period. Similar differences obtain in the use of the other three Tables.

42. I recommend therefore the abandonment of those Tables, and the adoption of the fixed Mēsha saṁkrānti times given in Table I. of the *Indian Calendar.* The Tables answered their purpose sufficiently well in the absence of definite information fixing the moment of beginning of each solar year, but now that we are in possession of that information we should do wisely to avoid them.

Note on the Kollam Era.

42A. The Kollam era, used on the West Coast of Southern India, from Mangalore to Cape Comorin, and in parts of the Tinnevelly district, began in K.Y. 3926 expired, A.D. 825–26. Its year is solar. Its twelve months are, in Malabar, named after the signs of the zodiac (but corrupted), while in Tinnevelly they have the names of the lunar months, "Chittirai" (for Chaitra), corresponding to the solar month Mēsha, and so on. In North Malabar the year begins with the sun's entry into the sign Kanyā, that is, with the solar month Āśvina; in South Malabar and Tinnevelly it begins with his entry into Siṁha, that is, with the solar month Bhādrapada. Consequently, in order to convert a given year of the Kollam era into an expired year of the Kaliyuga, we have to add to the figure of the former 3925 in North Malabar for the months Kanyā to Mīna inclusive, and 3926 for the remaining months, and in South Malabar and Tinnevelly 3925 for Siṁha to Mīna and 3926 for the remaining months. Very often, in this part of India, dates in inscriptions mention not only both the solar and lunar date, as for instance, "the sun being 21 days old in Vṛishabha, Wednesday, the fifth lunar day after new moon," but add the sign in which Jupiter then stood, *e.g.,* "Jupiter entering Mēsha," "Jupiter in Dhanus," and the like. Rules are given below for testing all such details of a date.

Initial day of a civil month.

43. A civil day in the Indian solar calendar begins at sunrise.[1] The first civil day of the solar month is found (*a*) from the moment of the initial saṁkrānti of the month, (*b*) from the application of

[1] True sunrise. But calculation must first be made for mean sunrise. The latter is 0 Laṅkā time, or, as usually considered, 6 a.m. The former depends on the latitude and longitude of the locality. Tables for calculating in true local time will be found in *Epigraphia Indica,* Vol. II., pp. 487 *ff* (*Jacobi*), and in my *Eclipses of the Moon in India.* It is only necessary for my present purpose to consider mean sunrise as the beginning of the solar day.

local rule. The rules obtaining are detailed in § 28, p. 12, of the *Indian Calendar*. They are four in number :—

(i.) *The Bengal rule.* When a saṁkrānti takes place between sunrise and midnight, or between 0 h. and 18 h. Laṅkā time, the solar month begins next day ; when it occurs after midnight the first day of the solar month is the next following, or third, day.

(ii.) *The Orissa rule,* for Amli and Vilāyatī eras. The first day of the month is the day of the saṁkrānti whenever it occurs. If, for instance, the saṁkrānti occurred at 23 h. 50 m. Laṅkā time, or 23 h. 50 m. after sunrise on a Friday, though this be only 10 m. before sunrise or about 5.50 a.m. on the Saturday, still the first civil day of the month is Friday.

(iii.) *The Tamil rule, or general rule for South India.* If the saṁkrānti takes place on any day before sunset or 12 h. Laṅkā time that day is the first civil day ; if it takes place after sunset, or between 12 h. and 24 h. Laṅkā time, the next day is the first day of the month.

(iv.) *The Malabar rule.* The day between sunrise and sunset is divided, according to its true length, into five parts ; and if the saṁkrānti occurs within the first three of them the month begins on the same day, otherwise it begins on the following day. Thus, if the length of a day from sunrise to sunset is 12 h. 30 m., its fifth part is 2 h. 30 m., and three of these parts is 7 h. 30 m. If a saṁkrānti occurred on a Friday 7 h. 25 m. after sunrise, the first civil day of the month began at sunrise on Friday ; but if it occurred at 7 h. 35 m. after sunrise, the first civil day of the month began at sunrise on Saturday.

Conversion of Results by the Ārya into Results by the Sūrya Siddhānta and vice versa.

44. The exact time fixed by a calculation according to the *Ārya Siddhānta*, made for the purpose of testing the date of an inscription, will be found generally to differ from the similar result made by a calculation when the *Sūrya Siddhānta* is used. There are three reasons for this :—

(1) The starting point for calculations, which is the astronomical beginning in time of the true solar year, *i.e.*, the moment of true Mēsha saṁkrānti, as fixed by the *Ārya*, differs, except in A.D. 496, when the two were together,[1] from the same moment as fixed by the *Sūrya Siddhānta*.

(2) The lengths of the true solar months according to the former differ slightly from those established by the latter. This is also the case with the mean months, but in them the difference is very small.

(3) In the case of calculation by the sun's mean motion a constant quantity called by us the *śōdhya*, viz., the difference between the time of the sun's arrival at the Mēsha saṁkrānti point when calculated by his true and his mean motions (§ 39A *above*), has to be applied to the time of true Mēsha saṁkrānti ; and this śōdhya interval is not quite the same according to the various authorities.

45. These differences necessitate the application, in the case of both true and mean computation, of two out of three corrections to a result obtained by one of these *Siddhāntas* if we desire to ascertain what that result would be by the other. I proceed to explain them more fully. In "true" calculations Corrections I. and II., in mean calculations Corrections I. and III., must be so applied.

46. The sidereal year of the *Ārya Siddhānta* is in length 365 d. 6 h. 12 m. 30 s., and that of the *Sūrya Siddhānta* is 365 d. 6 h. 12 m. 36.56 s. The time of the Mēsha saṁkrānti, according to the latter, is therefore earlier than it is according to the former by the amount of 6.56 s. per annum in years prior to A.D. 496, when the two were together, and by the same amount later in years subsequent to that date. The time of the true Mēsha saṁkrānti for every year according to the *Ārya Siddhānta* from A.D. 300 to 1900 is given in the *Indian Calendar*, Table I., and

Correction I. Year-lengths.

[1] See the "Additional Notes" at the beginning of this Volume.

the time according to the *Sūrya Siddhānta* from A.D. 1101 to 1900. Table XVII. below gives the time-differences for every year from A.D. 300 to 1900, in minutes[1] as well as (for convenience in luni-solar calculations) in the value of *a, b, c*. The signs + and − as given in Table XVII. are to be used when converting *Ārya Siddhānta* results to *Sūrya Siddhānta* results, and when the reverse process is required the signs are to be reversed. This enables anyone to ascertain by either authority the moment of true Mēsha saṁkrānti for any year of the 1600 years of the Tables.

47. Tables I. and XVII., however, give no information as to the exact moment of Mēsha saṁkrānti in years earlier than A.D. 300. For the use of those who may desire to know for such years at what moment this took place according to calculations made with the length of the year as fixed by the *Ārya Siddhānta*[2]—at what moment, that is, the Mēsha saṁkrānti would have been determined to have occurred if that *Siddhānta*, or other authority having the same year-length and starting calculations from the same base, had been used—the following note is inserted.

Note. The Julian year is 365 d. 6 h. long; the solar year of the *Ārya Siddhānta* is 365 d. 6 h. 12 m. 30 s. long; so that the *Ārya Siddhānta* year is 12 m. 30 s. longer than the Julian. This excess amounts to exactly five days in 576 years, and at this rate the *Ārya Siddhānta* Mēsha saṁkrānti is continually advancing on the Julian year. Conversely, that point is, in time, precisely five days earlier in every year removed 576 years backwards. Thus in Table I. of the *Indian Calendar* it will be observed that in A.D. 600 Mēsha saṁkrānti occurred on March 19th at 5 h. 30 m. Laṅkā time. In A.D. (600 + 576) 1176 it occurred on March 24th at 5 h. 30 m. Laṅkā time, and in A.D. 1752 on March 29th at the same hour. Therefore in A.D. 24 (600 − 576) it occurred on March 14th at 5 h. 30 m. Laṅkā time.

48. The times given in cols. 15, 17 of Table I. of the *Indian Calendar* are fixed on this principle. The annual increment being 12 m. 30 s., we have tabulated the difference in alternate years as 12 m. and 13 m.; and this same annual increment being $31\frac{1}{4}$ palas, we have tabulated the difference as 31 palas for three years and 32 palas in the fourth year. (*See also "Hint" No. 20, below*).

49. Thus to find the moment of Mēsha saṁkrānti for any year not given in the Tables, it is only necessary to find what that moment was in a year removed 576 years from it, whether earlier or later, or by any multiple of 576; and while retaining the hours and minutes, to alter the day backwards or forwards by five days for every such period.

50. It must be borne in mind, however, when working for Christian era years B.C., that, since there was no year A.D. 0–1,[3] the interval for such years is to be increased from 576 to 577. For 120 B.C., for instance, we work from the time of Mēsha saṁkrānti as fixed in (577 − 120) A.D. 457. For years of the Kaliyuga era the interval is always 576.

51. As to the week-days; since the same day of the month in consecutive Julian years is always one week-day later in each common year and two week-days later in each leap-year, we have, in an interval of 576 years, an advance of (576 + 144 =) 720 days. To this has to be added the five extra days resulting from the difference between the Julian and *Ārya Siddhānta* year-lengths in each cycle of 576 years. Total, 725 days, which, divided by 7, leaves remainder 4. So that we subtract four days from, or add them to, the week-day given for the Mēsha saṁkrānti of the base year, for every interval of 576 years removed from it backwards or forwards as the case may be. See, for instance, the examples given above (§§ 47, 50). The week-day corresponding to the Mēsha saṁkrānti day of A.D. 600 being 0, Saturday, the week-day of the Mēsha saṁkrānti day of A.D. 24 was (7 — 4 =) 3, Tuesday; and the similar day in A.D. 1176 was (0 + 4) 4, Wednesday. So the week-day corresponding to the Mēsha saṁkrānti day of A.D. 457 being 2, Monday, the week-day of the Mēsha saṁkrānti day of 120 B.C. was (9 — 4 =) 5, Thursday.

[1] This suffices for all practical purposes.
[2] We are not concerned with the *Sūrya Siddhānta* at so early a date.
[3] Between 1 B.C. and A.D. 1 there is no year. A.D. 0 is 1 B.C., and 0 B.C. is A.D. 1.

52. To show that the above processes yield accurate results and are not mere rough-and-ready approximations, I may state that at my request Mr. Sh. B. Dikshit specially worked out the times of the Mēsha saṁkrāntis in some years by the elements of the *Ārya Siddhānta* itself, in order that we might have a quite independent check on the figures which we obtained by the method just explained. One of these years was A.D. 499–500 (Śaka 422 current, K.Y. 3601 current). He found that by this independent calculation the moment of true Mēsha saṁkrānti of that year by the *Ā.S.* was Friday, March 19th, A.D. 499, at 6 gh. 11 p. Table I. has 6 gh. 9 p. on the same day.[1] The difference between the two amounts to 48 seconds, of which half at least, if not the whole, is attributable to fractions of vipalas.

53. Similar calculation direct by the *Ā.S.* for the Mēsha saṁkrānti in A.D. 78, Śaka 1 current, yielded Sunday, March 15th, at 11 gh. 55 p. Calculation by the process I have explained gives 11 gh. 52 p. 30 vip. on the same day, showing a difference of 1 m. The slight difference is not material, and on consulting Mr. Dikshit he advised a systematic adherence to our own system, in preference to direct calculation from the *Siddhānta*, as more likely to yield correct results.

Rule for finding Mēsha saṁkrānti for any year not given in Table I., by the Ārya Siddhānta.

54. The rule, then, for finding the true Mēsha saṁkrānti time by the *Ārya Siddhānta* of any year not already given in col. 1 of the *Indian Calendar* is as follows: Look in Table I. and take the day, week-day, hour and minute of the similar moment (*cols.* 13 *to* 17) in a year removed 576 years or a multiple of 576 years from the given year. For the day of the month deduct five days for every period of 576 years in the case of years earlier, or add the same for a similar period in the case of years later, than the year taken from Table I. For the week-day deduct or add four days similarly. Retain the hours and minutes given in Table I. for the year taken as base. The result is the moment of "true" Mēsha saṁkrānti for the given year. For mean Mēsha saṁkrānti add the śōdhya interval (*Corr. III. below*) by the Siddhānta concerned.[2]

Correction II. Month-lengths.

55. The Table on p. 10 of the *Indian Calendar* shows the lengths of true solar months according to both the Siddhāntas concerned, and these differ from one another. In consequence, even if there were no difference in the astronomical beginning of the solar year, the astronomical beginnings of subsequent solar months, *i.e.*, the moments of the saṁkrāntis, would not be the same by the two authorities. Table III. (p. cvii.) of the *Ind. Cal.* gives the collective duration of months from the Mēsha to each subsequent saṁkrānti by the two Siddhāntas; and I have repeated this in my new Tables, XVIII.A and XVIII.B, adding the *a, b, c* corresponding to that collective duration, and giving besides the difference in the lengths of each solar month between the saṁkrāntis, with the corresponding *a, b, c* for each. This helps to simplify calculations of all kinds; for when we have found the *a, b, c* for Mēsha saṁkrānti of any year we simply add to them the *a, b, c* given in the new Table for the interval to the required saṁkrānti, obtaining the desired result in one process instead of having to make two separate calculations. The *a, b, c* for any subsequent interval of days is obtained from Table IV. of the *Indian Calendar*, and of hours and minutes from Table V.

56. For the purpose of converting a "true" measurement result arrived at by the *Sūrya Siddhānta* into a similar result by the *Ārya Siddhānta*, and *vice versa*, we apply, for true Mēsha saṁkrānti, the correction (I.) given in Table XVII.; and for all subsequent saṁkrāntis we add the correction (II.) given in Table XVIII.C, which gives the time and *a, b, c* difference for each saṁkrānti between the two authorities. The first process alone must be used for the Mēsha saṁkrānti; both processes are required for all subsequent saṁkrāntis. (*See Examples* 13, 14, *below*.)

[1] (*See* § 162 *below, para.* 2, *and Note.*) It being a fact that in A.D. 499 mean Mēsha saṁkrānti by the *Ārya Siddhānta* took place precisely at noon on March 21st, it is also a fact that the true Mēsha saṁkrānti of that year occurred precisely at 2 h. 27 m. 30 s., or in Hindū reckoning at 6 gh. 8 p. 45 vip. Lankā time, on March 19th. Consequently, our tabulation in Table I. of 6 gh. 9 p. is correct.

[2] In Table XXXVIII.C. I have given the moments of occurrence of mean Mēsha saṁkrānti by the *Ārya Siddhānta* for a period of 576 years, viz., from A.D. 499 to 1075.

57. All calculations in solar reckoning made by the mean system must have for their starting point the moment of the mean and not of the true Mēsha saṁkrānti. Between these two there is an interval called the śōdhya. (*See* §§ 16, 39A, *&c.*) As stated in the *Indian Calendar* (§ 26, *pp.* 11, 12) we take this interval as a constant. According to the *Ārya Siddhānta* it consists of 2.1475694 d., or 2 d. 8 gh. 51 p. 15 v., or 2 d. 3 h. 32 m. 30 s., and according to the *Sūrya Siddhānta* of 2.170694 d., or 2 d. 10 h. 14 p. 30 v., or 2 d. 4 h. 5 m. 48 s.; the difference between the two amounts to 1 gh. 23 p. 15 v., or 33 m. 18 s., by which amount the latter is longer than the former. In terms of our *a* this difference amounts to 7.83, and therefore we take *a* = 8 as the working difference between the two Siddhāntas in this respect.

Correction III. Śōdhya-lengths.

58. In mean calculations on the *a, b, c* system we are only concerned with *a*, which gives us the mean longitudinal distance of the moon from the sun at any moment. The *Ārya Siddhānta* śōdhya is, in terms of *a*, 727, and the *Sūrya Siddhānta* śōdhya, in terms of *a*, is 734. As before explained every figure of *a* in our method of work by the true system has been reduced by a certain amount to compensate for amounts added to *b* and *c*, so that all processes may be additive; and when we have, as in mean calculations, to use *a* independently of *b* and *c*, we first find *a* in the usual manner, and then restore it to its proper dimensions by adding the amount by which it was artificially reduced. This amount was for *b* 140.2 and for *c* 60.4, total 200.6. Taken by itself the round figure corresponding to this should be 201, and this is what should properly be used for all direct calculations. But when we are merely converting a result by one of our two Siddhāntas into a result by the other, and are doing so by using the figure of *a* for the difference between the two, which figure I have stated exactly as 7.83 and roughly as 8, the regular addition to the calculated *a* should not be 201, but 200, since 200.6 + 7.83 = 208.43, and the decimal is less than half an unit. On the other hand, when using the Siddhānta difference 7.83 as a minus quantity the proper value of the constant will be 201, since 201 — 8 = 193, which is the nearest whole figure to (200.6 — 7.83) 192.77. For ordinary calculation however, the value of the śōdhya constant may be taken as 200, which is a convenient figure; but for closer work it will be well to use the decimals in the calculation, and then take the nearest whole figure.

59. The time and longitude of the other mean saṁkrāntis is found from the time of mean Mēsha saṁkrānti by adding to the latter the time-difference, or longitudinal (*a*) difference, given as the collective duration against each saṁkrānti in col. 5 of Table XIX. (A or B, whichever Siddhānta is being utilised),[1] and if these particulars are required for two consecutive saṁkrāntis, as in calculations for mean intercalated months, then by adding to the *a* of the first the *a* of the interval to the second, as given in col. 6 of those Tables.

60. When the moment of a mean saṁkrānti has been found by the *Sūrya Siddhānta* it is converted to the same moment according to the *Ārya Siddhānta* by (1) applying Correction I. (Table XVII., with sign reversed), and Correction III. (in time — 33 m. 18 s., or, in *a*, — 8); for the reverse process we apply Correction I. (Table XVII. as it stands) and Correction III. (+ 33 m. 18 s. or, in *a*, + 8). (*See Examples* 17, 36-40.)

61. All this is very simple in practice, as the following example will show: The year A.D. 1096-7 was close to the time when the *Sūrya* in many parts of India supplanted the *Ārya Siddhānta*, and we want to know the times of mean Mēsha and mean Vṛishabha saṁkrāntis, as well as the mean moon's distance from the sun, or the value of *a*, at each—and these by both the Siddhāntas.

[1] The only differences between these two are in connection with the Kumbha and Mīna saṁkrāntis. I have given the exact figures in Tables XIX.A, XIX.B, cols. 3, 4, as they may be found useful for other purposes, but in practice vipalas and seconds below the half may be ignored.

First for the *Ārya Siddhānta* :

	d.	w.	h.	m.
True Mēsha saṁk. by *Ār. Siddh.* (*Table I., cols.* 13, 14, 17) .	(83)	1	12	50
Ā. S. śōdhya	(2)	2	3	32
Mean Mēsha saṁk. by *Ā. S.*, Tuesday, March 25th (*Table IX.*) .	(85)	3	16	22
Interval to mean Vṛishabha saṁk. (*Table XIX.*)	(30)	2	10	31
Mean Vṛishabha saṁk. by *Ā. S.*, Friday, April 25th . . .	(116)	6	2	53

Convert these times to *Sūrya Siddhānta* figures. By that authority mean Mēsha saṁkrānti took place on (March 25th, 16 h. 22 m. +, by Corr. I., 1 h. 6 m. +, by Corr. III., 33 m.) March 25th at 18 h. 1 m., and mean Vṛishabha saṁkrānti took place on (April 25th, 2 h. 53 m. + 1 h. 6 m. + 33 m.) April 25th at 4 h. 32 m.

For the mean moon's distance from the sun at each saṁkrānti, or the value of *a*, let it be assumed that the *a* of the true Mēsha saṁkrānti by the *Ā. S.* was 8751.[1] To this add (śōdhya, *a* =) 727 and (the constant) 201. Total, 9679. This is the value of *a* at mean Mēsha saṁkrānti by that Siddhānta.

Convert this to the same by the *Sūrya Siddhānta* by (Corr. I.) + 15 and (Corr. III.) + 8. Total, 9702. This is the figure for the *t*, which in mean calculation is the same as *a*, tabulated, for the *Sūrya Siddhānta*, in Table I., *Indian Calendar*, for the year in question.[2]

To the values of *a* by the two authorities thus found, viz., *Ā. S.* mean Mēsha saṁkrānti 9679, and the same for the *S. S.* 9702, add in each case the interval to the next saṁkrānti (Table XIX., col. 6), viz., 307, and we have the *a* of mean Vṛishabha saṁkrānti by the *Ā. S.* 9986, and by the *S. S.* 9 (as tabulated in Table I., col. 11*a*.)

[Incidentally this proves that the lunar month intercalated in this year according to the *Ārya Siddhānta* was not Vaiśākha, as was the case by the *Sūrya Siddhānta*, but Jyēshṭha.]

62. I have given in full, so that they may be thoroughly understood, the details of this process, but in practice the use of Corr. III. for conversion of results from the *Sūrya Siddhānta* saṁkrānti figures as given in Table I. of the *Indian Calendar*, cols. 9, 11, 9A, 11A, to the same saṁkrānti figures by the *Ārya Siddhānta* for the year A.D. 1096–97, simply amounts to the following :—

S. S. 9702 — 15 (Corr. I.) — 8 (Corr. III.) = *Ā. S.* 9679.

Mēsha saṁkrānti, true and mean, according to the Original Sūrya Siddhānta.

62A. Since it may often be found necessary to examine a date by the *Original Sūrya Siddhānta*, I proceed to show how, from the information at present available, we may find the necessary and most important starting-point for calculations by it, viz.: the moment of Mēsha saṁkrānti, either true or mean.

The moment of occurrence of a mean saṁkrānti is found from any given or calculated moment of a true saṁkrānti by adding to the latter the proper value of the śōdhya. The moments of all true Mēsha saṁkrāntis according to the *Ārya Siddhānta* are given in Tables XXXVIII.A and XXXVIII.B and Table I. of the *Indian Calendar* from 59 B.C. to A.D. 1950 (*see also Example* 3 *below*), but for our present purpose only the earlier years are required ; the same rules, however, apply to all. Śōdhya by the *Ārya Siddhānta* is a constant quantity and, ignoring seconds, = 2 d. 3 h. 32 m. Śōdhya by the *Original Sūrya Siddhānta* is declared by Sh. B. Dikshit to be 2 d. 5 h. 45 m. He takes this also as a constant ; and we may do the same, since, though there was possibly a slight variation during the course of 2000 years we are practically only concerned with about, at the utmost, a period extending over 1000 years, for

[1] I have calculated this independently and found it correct.

[2] If the addition for the constant had been taken as 200, for convenience, the difference of one unit (= 4.25 minutes) would in this case have been immaterial.

which his calculation may be assumed to be sufficiently accurate. The Table given below in § 162 shows the time-difference to be applied in any year to the moment of *mean* Mēsha saṁkrānti according to the *Ārya Siddhānta* in order to obtain that moment according to the *Original Sūrya Siddhānta.*

I shall first give the rule for work according to the full process, which explains itself, and afterwards give a rule for shorter work which may be adopted in practice.

(A) *The full working-rule.* Take down the day, hour, and minute for true Mēsha saṁkrānti in the given year by the *Ārya Siddhānta.* Add the amount of the *Ārya Siddhānta* śōdhya. This gives the moment of mean Mēsha saṁkrānti by that authority.[1] Apply the time-difference for the year as given in the Table in § 162. This gives the moment of mean Mēsha saṁkrānti by the *Original Sūrya Siddhānta.* Deduct the amount of the *Original Sūrya Siddhānta* śōdhya. This gives the required moment of true Mēsha saṁkrānti by the latter. We are thus enabled to obtain the moments of both true and mean Mēsha saṁkrānti by the *Original Sūrya Siddhānta,* as required.

For an example take the year A.D. 300. We want the moments of true and mean Mēsha saṁkrānti by the *Original Sūrya Siddhānta* in that year. (M.S.=Mēsha saṁkrānti ; Ā.S.=*Ārya Siddhānta.* O.S.S.=*Original Sūrya Siddhānta*) :—

	d.	h.	m.
True M.S. by *Ā.S.* A.D. 300, Table I.	16 March	15	0
Add śōdhya by the *Ā.S.*	2	3	32
Mean M.S. by *Ā.S.*	18 March	18	32
Deduct (*Table in* § 162) for difference of 199 years (*i.e.*, A.D. 499 — 300) 10 m. + 9 m. + 54 s. = 19 m. 54 s., or			— 20
Mean M.S. by *O.S.S.*	18 March	18	12
Deduct *O.S.S.* śōdhya	— 2	— 5	— 45
True M.S. by *O.S.S.*	16 March	12	27

True Mēsha saṁkrānti according to the *Original Sūrya Siddhānta,* therefore, took place in A.D. 300 on March 16th at 12 h. 27 m. after mean sunrise. Mean Mēsha saṁkrānti by that authority took place in that year on March 18th at 18 h. 12 m. after mean sunrise.

(B) *The shorter rule.* It will be observed that the difference in results between the two authorities depends on two elements, (i) the difference in the value of the śōdhya between the two Siddhāntas, and (ii) the time-difference given in the Table in § 162. Since we take the value of (i), the śōdhya, as a constant in each case, the difference between them is also a constant. It amounts to 2 d. 5 h. 45 m. 12 s.— 2 d. 3 h. 32 m. 30 s., or 2 h. 12 m. 42 s., by which interval the true Mēsha saṁkrānti by the *Original Sūrya Siddhānta* was in every year earlier than the moment of true Mēsha saṁkrānti by the *Ārya Siddhānta.* The time-difference (ii) shown in the Table in § 162 varies every year. We can, therefore, take at once the moment of true Mēsha saṁkrānti for any year according to the *Ārya Siddhānta ;* deduct (i) the constant, or śōdhya-difference, roughly 2 h. 13 m. ; apply (ii) the time-difference for the year (*Table in* § 162, p. 57) ; and thus obtain the moment of true Mēsha saṁkrānti by the *Original Sūrya Siddhānta.*

We take, again, the year A.D. 300 :—	h.	m.	d.	h.	m.
True M.S. by *Ā.S.* (*Table I.*)			16 March	15	0
Deduct—(i) constant, śōdhya-difference . .	— 2	13			
(ii) Time-difference for 199 years (*Table in* § 162)	—	20			
Total	— 2	33		— 2	33
True M.S. by O.S.S.			16 March	12	27

This result is precisely the same as that obtained by the longer process.

[1] Or obtain the same by use of Table XXXVIII.C.

62B. It will be well that I should point out clearly (the reason will be obvious from what has gone before) that a calculator must not be tempted to apply the time-difference given in the Table in § 162 to the moment found for *true* Mēsha saṁkrānti according to the *Ārya*, thinking thereby alone to obtain the moment of *true* Mēsha saṁkrānti by the *Original Sūrya Siddhānta*. This would be to ignore the difference in the śōdhya value by the two authorities.

Mēsha saṁkrānti, true and mean, according to the Brāhma Siddhānta.

62C. The times of occurrence of the true and mean Mēsha saṁkrāntis of each year according to the *Brāhma Siddhānta* of Brahmagupta can be obtained on the same principle as in the case of the *Original Sūrya Siddhānta;* but, for the amount of time-difference between the *Brāhma Siddhānta* and the *Ārya Siddhānta* (the moment of each year's Mēsha saṁkrānti by which is given in Table I.), we must use the Table given in § 167A below;—and for the śōdhya-value we have to use a different quantity. The Table in § 167A explains itself.

62D. As to the śōdhya-value, it is plain that since the *Brāhma Siddhānta* was only composed in the year A.D. 628, we shall never require, except for speculative purposes, to calculate for any earlier year than that; and as that year is the year K.Y. 3729 expired, we need not trouble ourselves at present with any value of the śōdhya other than for the centuries embraced in the period K.Y. 3000 to 5000. These values are, as decided by Dr. Schram :—

In K.Y.	3000, 2.172736 days,	or	2 d. 4 h. 8 m. 44.39 s.
,,	4000, 2.172991	,,	2 d. 4 h. 9 m. 6.42 s.
,,	5000, 2.173246	,,	2 d. 4 h. 9 m. 28.45 s.

The 1000-year difference is 22.03 s. and for the whole period of 2000 years is only 44.06 s. We may therefore take the value for the whole period connected with the *Brāhma Siddhānta* as a constant, and as amounting to 2 d. 4 h. 9 m.; only using the actual values whenever a very close case demands exceptional accuracy.

62E. This point settled, we are enabled to make the necessary calculation. As an example I take the year A.D. 1000, or K.Y. 4101 expired. And as in the case of the *Original Sūrya Siddhānta*, I give two methods of work, showing first the full work, and secondly a shorter process by which the same result can be obtained.

(A) *The full working-rule.* This is, *mutatis mutandis*, similar to the full working-rule for the *Original Sūrya Siddhānta* given in § 62A :—

	d.	*h.*	*m.*
True M.S. by the *Ā.S.* (*Table I.*)	22 March	16	50
Add *Ā.S.* śōdhya	2	3	32
Mean M.S. by the *Ā.S.*	24 March	20	22
Deduct (*Table in* § 167A) for 4101 years, 23 h. 20 m. + 35 m. + 21 s. Ignoring the seconds		— 23	— 55
Mean M.S. by the *Brāhma Siddhānta*	23 March	20	27
Deduct *Brāhma Siddh.* śōdhya	— 2	— 4	— 9
True M.S. by the *Brāhma Siddh.*	21 March	16	18

According, therefore, to the *Brāhma Siddhānta*, true Mēsha saṁkrānti of A.D. 1000 occurred on March 21st at 16 h. 18 m., and mean Mēsha saṁkrānti on March 23rd at 20 h. 27 m., after, in each case, mean sunrise.

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(B) *The shorter rule.* The value of the śōdhya according to the *Ārya Siddhānta* being a constant, viz. 2 d. 3 h. 32 m., and the śōdhya according to the *Brāhma Siddhānta* being taken by us as a constant, viz. 2 d. 4 h. 9 m., we observe that the difference between these two values amounts in every year with which we have any concern, to 37 m., by which period a saṁkrānti calculated by the *Brāhma* was always earlier than the same as calculated by the *Ārya Siddhānta.* We therefore take the time of true Mēsha saṁkrānti of the given year according to the *Ārya Siddhānta* from Table I., deduct the time-difference given in the Table in § 167A for the number of the expired year of the Kaliyuga, and deduct also, for the śōdhya-diffe ence, 37 m. The result is the time of true Mēsha saṁkrānti according to the *Brāhma Siddhānta.* The time of mean Mēsha saṁkrānti is obtained by adding to this the amount of the śōdhya by that authority, as stated, viz., 2 d. 4 h. 9 m.

Working by the same year, K.Y. 4101 expired, the process is as follows :—

	h.	*m.*	*d.*	*h.*	*m.*
True M.S. by the *Ā.S.* (*Table I.*)			22 March	16	50
Deduct (*Table in* § 167A) for 4101 years, as above .	23	55			
Deduct also for śōdhya-difference, as explained .	0	37			
Total deduction	24	32		— 24	— 32
True M.S. by the *Brāhma Siddhānta*			21 March	16	18

This result is the same as that obtained by the longer method.

Mēsha saṁkrāntis, true and mean, according to the Siddhānta Śirōmaṇi.

62F. The *Siddhānta Śirōmaṇi*, written by Bhāskarāchārya in A.D. 1150, K.Y. 4251 expired, gives the length of the solar year as identical with that of the *Brāhma Siddhānta,* with which also it agrees as to the moment of the epoch of the Kaliyuga era ; so that the Table given below in § 167A applies equally to both these authorities in their respective relations to the *Ārya Siddhānta.* It also agrees with the *Brāhma Siddhānta* as to the value of the śōdhya in K.Y. 0. ; but reference to Dr. Schram's Table shows that in later centuries there was a change, and that the two authorities differ. Consequently, while these two authorities are entirely in agreement as to the position of Jupiter at any time (§ 163), in calculating which we have to consider the value of the śōdhya only in K.Y. 0., they are not always in agreement as to the moment of occurrence of Mēsha saṁkrānti, because their śōdhya-values in later years are different. That is to say, we can calculate the time of occurrence of Mēsha saṁkrānti in any year by the *Siddhānta Śirōmaṇi* partly with the aid of the Table in § 167A, but in completing that calculation we must use a śōdhya-value different from that of the *Brāhma Siddhānta.*

62G. Since the *Siddhānta Śirōmaṇi* came into existence in K.Y. 4251 expired, we need consider the length of the śōdhya interval according to it only for the period K.Y. 4000 to 5000. Dr. Schram has settled for us its value at either end of that millennium. In K.Y. 4000 it was 2.179364 days, or 2 d. 4 h. 18 m. 17.05 s., and in K.Y. 5000 it was 2.181213 days, or 2 d. 4 h. 20 m. 56.8 s. The total change during the thousand years in question was 2 m. 39.75 s. If we divide this thousand years into centuries, for convenience of calculation, we find that the centennial change amounts to + 15.975 s. I give below, therefore, a Table showing in col. 3 the exact value of the *Siddhānta Śirōmaṇi* śōdhya in the years noted in cols. 1 and 2 ; and I have added in col. 4 the figures to be used when working by the longer, and in col. 5 the figures to be used when working by the shorter, rule.

TABLE SHOWING THE VALUE OF THE ŚŌDHYA FROM K.Y. 4000–5000 BY THE **Siddhānta Śirōmaṇi** FOR USE IN CALCULATING THE TIME OF MĒSHA SAṀKRĀNTI BY THAT AUTHORITY.

In the year K.Y. expired.	In A.D.	Exact value of śōdhya as fixed by Dr. Schram for the year entered in col. 1.				Value of śōdhya to be used in calculation by (i) the longer rule.			Difference between *Siddh. Śirō.* and *Ārya Siddhānta* value of the śōdhya. For use by (ii) the shorter rule.
1	2	3				4			5
		d.	*h.*	*m.*	*s.*	*d.*	*h.*	*m.*	*Minutes.*
4000	899	2	4	18	17.05	2	4	18	46
4100	999	2	4	18	33.025	2	4	19	46
4200	1099	2	4	18	49	2	4	19	46
4300	1199	2	4	19	4.975	2	4	19	47
4400	1299	2	4	19	20.95	2	4	19	47
4500	1399	2	4	19	36.925	2	4	20	47
4600	1499	2	4	19	52.9	2	4	20	47
4700	1599	2	4	20	8.875	2	4	20	48
4800	1699	2	4	20	24.85	2	4	20	48
4900	1799	2	4	20	40.825	2	4	21	48
5000	1899	2	4	20	56.8	2	4	21	48

62H. The calculations for Mēsha saṁkrānti are to be made exactly on the same principle as in the case of similar calculations for the *Original Sūrya* and *Brāhma Siddhāntas*, but using the above Table for śōdhya-values. The rules have been sufficiently explained, and need not be repeated.

For an example I take the years A.D. 1150 (K.Y. 4251 expired) and 1250 (K.Y. 4351 expired).

(i) *The full working-rule.* [It may be as well to state that the amounts of deduction made in the calculation below according to the Table in § 167A are obtained by adding together the figures given in that Table for millenniums, centuries, decades and odd years of the expired year of the Kaliyuga.] :—

	For A.D. 1150.			*For A.D.* 1250.		
	d.	*h.*	*m.*	*d.*	*h.*	*m.*
True M.S. by the *Ā.S.* (*Table I.*)	24 March	12	5	25 March	8	55
Add *Ā.S.* śōdhya (constant)	+ 2	3	32	+ 2	3	32
Mean M.S. by the *Ā.S.*	26 March	15	37	27 March	12	27
Deduct (*Table in* § 167A)	— 1	0	48	— 1	1	23
Mean M.S. by *Siddh. Śirō.*	25 March	14	49	26 March	11	4
Deduct śōdhya by the *Siddh. Śirō.* (*Table in Text, col.* 3)	— 2	4	19	— 2	4	19
True M.S. by *Siddh. Śirō.*	23 March	10	30	24 March	6	45

(ii) *The shorter rule.* Work for the same years :—

	d.	*h.*	*m.*	*d.*	*h.*	*m.*	*d.*	*h.*	*m.*	*d.*	*h.*	*m.*
True M.S. by the *Ā.S.* (*Table I.*)							24 March	12	5	25 March	8	55
Deduct respectively—												
(*Table in* § 167A) .	— 1	0	48	— 1	1	23						
(*Table in* § 62G, *col.* 5)	—		47	—		47						
Total . . .	— 1	1	35	— 1	2	10	— 1	1	35	— 1	2	10
True M.S. by *Siddh. Śirō.* . .	. . .			. . .			23 March	10	30	24 March	6	45

We thus learn that the moment of true Mēsha saṁkrānti as calculated by the *Siddhānta Śirōmaṇi* occurred in A.D. 1150 on March 23rd at 10 h. 30 m. after mean sunrise, differing by more than a day from the same as calculated by the *Ārya Siddhānta*; and that in A.D. 1250 it occurred by the *Siddhānta Śirōmaṇi* on March 24th at 6 h. 45 m. after mean sunrise, with a similar difference between it and the *Ārya Siddhānta*.

[Unfortunately, I have no means at hand for checking and comparing these results both by the *Brāhma Siddhānta* and *Siddhānta Śirōmaṇi*, but they are decidedly suggestive; for it would seem necessary, after observing these results, that a number of records hitherto examined only by the *Ārya* or *Sūrya Siddhāntas* should again be subjected to scrutiny. The result would teach us till how late and in what parts of India the other authorities were used, and would form a most useful element in the discovery of mediæval forgeries.]

N.B. In all these cases there may be an error in the result of one minute, if we begin our calculations by taking the time of true Mēsha saṁkranti according to the *Ārya Siddhānta* from Table I. of the *Indian Calendar*, which does not take account of seconds. But if greater accuracy is desired, it can be obtained by applying the rule given in "Hint" No. 20 below.

LUNI-SOLAR RECKONING.

63. Before proceeding to consider this subject a few notes may not be amiss.

The meaning of our *w*, *a*, *b*, *c* and *t* is explained above in the Introduction.

A true lunation is the time actually taken by the moon to move through one synodical revolution, new-moon to new-moon. Its length varies constantly from 30 d. 1 h. 15 m. to 29 d. 0 h. 40 m., in consequence of her orbit being elliptical and because of the earth's unequal velocity at different parts of its orbit round the sun.

A mean lunation, or mean synodic lunar month, consists, according to modern science and the *Sūrya Siddhānta*, of 29 d. 12 h. 44 m. 2.87 s. Authorities differ only in the fraction of the second.

While the daily motion of the moon varies like that of the sun in consequence of her orbit being an ellipse, being more rapid when near perigee than when she is near apogee, so that during part of her revolution she is six or seven degrees behind, and in part six or seven degrees in advance of, her mean place, this retardation and acceleration does not, as in the case of the sun during the 5000 years of the Kaliyuga, always take place in the same region of the heavens; since the line of the moon's apsides makes a complete revolution once in a little less than nine years, while the movement of the sun's line of apsides is exceedingly slow.

A tithi is one-thirtieth of a synodic lunation, that is to say, it is the time occupied by the moon in increasing her distance from the sun in longitude by 12 degrees, the thirtieth part of the circle of 360 degrees.

A mean tithi is the exact one-thirtieth of a mean lunation, viz., 23 h. 37 m. 28.093 s.

A true tithi is the time in true longitude, and varies in length from 21 h. 34 m. 24 s. to 26 h. 6 m. 24 s.

Table I. of the *Indian Calendar*, cols. 21-25, gives, according to the Siddhāntas generally, but more particularly according to the *Sūrya Siddhānta*, the elements of luni-solar reckoning for mean sunrise at Laṅkā (Ujjain) on the first civil day of each luni-solar year, *i.e.*, of the sunrise next following the moment of the new-moon next after apparent Mīna saṁkrānti.

64. *Amānta and pūrṇimānta systems of lunar months.* The amānta lunar month begins astronomically at the moment of new-moon; the pūrṇimānta lunar month begins astronomically at the moment of the previous full-moon. In each case the first tithi of the lunar month begins at that moment; and the civil day at whose sunrise this first tithi is current is the first civil day of the lunar month.

The beginning of the luni-solar year.

65. Astronomically the Chaitrādi luni-solar year—the year, that is, which is held to begin with the beginning of the first tithi of the bright half of the amānta month Chaitra—has for its initial point the moment of the new-moon which comes next after the Mīna saṁkrānti, the last saṁkrānti of the solar year. It is always the new-moon next before the Mēsha saṁkrānti except when Chaitra is an intercalary month. The time of the apparent sidereal Mēsha saṁkrānti for each year is given in Table I. of the *Indian Calendar* (*cols.* 13 *to* 17, *and* 17*a*). For civil purposes the luni-solar year begins generally at sunrise of the day on which the first tithi of Chaitra is current; that is to say, at sunrise of the day next following the moment of the new-moon of Chaitra.[1] The *a*, *b*, *c* for this moment (taken as mean sunrise at Laṅkā) are given in the same Table, cols. 19 to 25, with the lunation-parts and tithis expired since the moment of new-moon. Nothing more is required, therefore, for commencement of work by the sidereal apparent Mēsha saṁkrānti.

66. But since there is also a mean Mēsha saṁkrānti to be sometimes calculated, which is always later than the apparent Mēsha saṁkrānti by two days and some hours, as well as a tropical Mēsha saṁkrānti, it follows that in work under the mean system, or for the tropical year, the new-moon which marks the beginning of the luni-solar year may not always be the same.

67. Take first the mean system. If a mean new-moon occurs between the moments of true and mean Mīna saṁkrānti, then the month called Chaitra under the mean system will be a month later than the month called Chaitra under the true system; because it is the rule that the lunar year begins with the new-moon next after the Mīna saṁkrānti, and in this case the mean new-moon which occurred next after mean Mīna was a month later than the true new-moon next after true Mīna saṁkrānti. Therefore if we use the mean system, Chaitra is the month *succeeding* the month called Chaitra under the true system; and under the mean system the previous luni-solar year may be a month longer than under the true system, in consequence of having an intercalary lunar month. In the *Indian Calendar*, Table I., all the intercalations of months, both true and mean, were carefully registered; but we unfortunately omitted to frame a Table for, or enter in cols. 19 to 25, the necessary mean-system figures (*d*, *w*, *a*, *b*, *c*) for sunrise on the initial civil day of the years following those in which an intercalation of a lunar month has taken place under that system, but not under the true system. The figures in those columns for the third year remain unaltered, since in the second of those years there is always an intercalation of a month under the true system and none by the mean system, the civil beginning of the third year being thus the same under both.

68. This omission I rectified two years after the publication of the *Indian Calendar* by the Table and note given at pp. 12, 13 of my "*Eclipses of the Moon in India*," and I now reproduce the whole in Table XXIV. below, which contains the necessary mean-system figures for the years noted. *Whenever therefore the mean system of intercalations is used* the figures given for the years mentioned in those columns must be substituted for the figures in the corresponding columns of Table I. They cover the period from A.D. 300 to 1100.

69. One example will suffice. Take the years A.D. 309, 310, 311. In A.D. 310 a true new-moon took place on February 16th, and another on March 17th. True Mina saṁkrānti occurred by the *Ārya Siddhānta* on February 14th, and mean Mīna on February 17th. The February new-moon (both true and mean) fell between the two. Therefore by the true system the initial moon of the year was that of February 16th, and the luni-solar year began at sunrise on February 17th, as entered in Table I., col. 19. But by the mean system the initial new-moon was that of March 17th, and the luni-solar year

[1] See the third paragraph of § 52, p. 31, *Indian Calendar*, and p. 55, note 2.

began at sunrise on March 18th, as entered in Table XXIV. The years A.D. 309–10, 310–11, 311–12, correspond to K.Y. 3411, 3412, 3413 current. A lunar month had to be intercalated by the mean system in K.Y. 3411,[1] in which year there was no intercalation by the true system. In the year K.Y. 3412 Vaiśākha was intercalated under the true system (*Table I., col.* 8), while there was no intercalation under the mean system; so that the beginning of the luni-solar year K.Y. 3413 was the same (*Table I., cols.* 19–25) under both systems. The beginnings of the years K.Y. 3411, 3413, therefore, are the same as given in Table I. for both systems, but while that Table for K.Y. 3412 stands if the "true" system is used, Table XXIV. must be substituted for Table I. if the mean system is used.[2]

70. Although, as I have stated, it is most improbable that Hindū calculators ever used the tropical year for the purpose of preparing ordinary calendars, it is necessary to notice them because it is possible that occasionally (though no instance has as yet been discovered) the date of a record may have been associated with a tropical, and not with a sidereal saṁkrānti. And for that reason attention must be called to the fact that whenever, subsequent to the year of coincidence (§ 34), a new-moon falls between the moments of the tropical and sidereal Mīna saṁkrāntis, the tropical luni-solar year will begin a lunar month earlier than the ordinary sidereal luni-solar year of our Tables, for reasons similar to those considered in §§ 66 to 69. There is no need to frame Tables for such years. It is only necessary to call attention to the fact. The point to be remembered is that, though the tithi will, when worked according to rule, be correct by our Tables, the name of the month may be different; the month to which the tithi belongs being, if tropical saṁkrāntis were used, a month later or earlier than the month obtained from our Tables—later in years in which the tropical Mīna saṁkrānti is later than the sidereal Mīna saṁkrānti of the Tables, and earlier when it is earlier.

The Ordinary Civil Beginning.

71. So much being said by way of caution, I return to the ordinary civil beginning of the Chaitrādi luni-solar year, or the year which astronomically begins with the new-moon of amānta Chaitra. *Mutatis mutandis*, the same principles apply to years which begin with other months. (*See* § 52, *p.* 31 *of the Indian Calendar.*)

72. The civil beginning of such a year is, in amānta reckoning, supposed to be, as already stated, at sunrise (probably taken as true sunrise in local almanacs, but by us as mean sunrise for preparation of general working Tables; and this as representing for time-measurement 6 a.m. on the meridian of Laṅkā, alias of Ujjain, Greenwich east longitude 75° 46′, — time-correction from Greenwich + 5 h. 3 m.) —at sunrise of the day on which the first tithi of the bright half of Chaitra, alias Chaitra śukla pratipadā or Chaitra śukla 1st, is current at sunrise. And in columns 19, 20 of Table I. of the *Indian Calendar*

[1] This month by regular rule was Māgha.

[2] The above is the easiest method of work, but if care be used in noting the correspondence of months the figures given in the *Ind. Cal.* (cols. 19 to 25 of Table I.) may be equally used under the mean system. Thus if we have to find, in a date of an inscription, the week-day and other particulars for a tithi in amānta Chaitra and in amānta Jyēshṭha of K.Y. 3412 current, as calculated by the mean system, we can either work as directed in the text, or we can make the months correspond with those found by the *Indian Calendar*, Table I. In the latter case all we have to do is to remember that the month called "Chaitra," K.Y. 3412 current, under the mean system, was, under the true system, called "adhika Vaiśākha," since Māgha was intercalated in the previous year under the mean system and Vaiśākha was intercalated in K.Y. 3412 under the true system. "Chaitra" of the mean system was the second month, adhika Vaiśākha, of the true system. Similarly "Jyēshṭha" of the mean system was the fourth month of the true system; and, because of the intercalation of Vaiśākha under the true system, it was the same month, Jyēshṭha, both in place and name as the Jyēshṭha of the true system found from Table I., cols. 19 to 25, of the *Ind. Cal.* Working therefore as in the text by Table XXIV., by the mean system, the months to be calculated are Chaitra (1st) and Jyēshṭha (3rd); but equally correctly the same months can be calculated by the "true" system, using Table I. as it stands, but working for adhika Vaiśākha (2nd month) and Jyēshṭha (4th).

we gave the day of the month A.D. and the week-day on which that first tithi—taken as an apparent or true, not mean, tithi—ended in each year. Cols. 21, 22 show how many lunation-parts of that tithi, our "*t*," had expired at mean sunrise, or by how many of those lunation-parts earlier than mean sunrise on that day the actual moment of new-moon had occurred; and how much of the first tithi of Chaitra had expired at that mean sunrise. Cols. 23, 24, 25 give the *a*, *b*, *c* for the same moment (§§ 19, 20 *above*), *i.e.*, for mean sunrise on that civil day. We can therefore start all calculations connected with lunar months from that point. Every successive lunar month begins civilly on the day on which the 1st śukla tithi of the lunar month is current at sunrise.

73. If it is desired to find the actual moment of the Chaitra new-moon we calculate thus—(col. 21 gives the *t* elapsed, and the mean-time equivalent will be found in Table X. under the head "Tithi-index, *t*.") Take, for instance, the year K.Y. 4648 expired, A.D. 1547. At mean sunrise, or 6 a.m., on Tuesday, March 22nd, as we find from Table I., col. 21, 183 lunation-parts had elapsed. From Table X. we have 183 = 7 h. 5 m. + 5 h. 53 m., or new-moon occurred 12 h. 58 m. earlier, or at 5.2 p.m. on Monday, March 21st. This is a close approximation. Absolute accuracy can only be obtained by the full work shown in Examples 20, 21, pp. 91, 93 below.

74. The complete method of work is detailed in § 139, pp. 77–83, of the *Indian Calendar.*

Amānta and pūrṇimānta systems.

75. By the amānta system the lunar month ends with the moment of new-moon; by the pūrṇimānta it ends with the moment of full-moon. Calculation for the time of these moments is unaffected by difference of systems; the difference being solely in the nomenclature of the fortnights. Thus the second or dark half, beginning with the moment of full-moon, of amānta Phālguna does not, in the pūrṇimānta system belong to Phālguna but to Chaitra; but the first or bright half which follows belongs under both systems to Chaitra. The tithis of the same dark half are tithis of Phālguna in the amānta system and of Chaitra in the pūrṇimānta system; and the tithis of the following bright half are tithis of Chaitra by both systems.

76. In working therefore for a bright half, or śukla, tithi, we know that the month to which it belongs bears the same name all over India; but in working for a dark half, or kṛishṇa, tithi, we must bear in mind that in different parts of India it is considered as belonging to different months; so that if we make a mistake about this we may be a whole month wrong in the end. (*See Ind. Cal.*, § 13, *p.* 4; and, for the effect of the different systems on the naming the fortnights of intercalated months, § 45, *Table, p.* 26, and § 51, *p.* 30; also *Table II., Part* 1.)

Computation by true lunar months and tithis.

77. Full details for work are given in the *Indian Calendar*, § 139, pp. 77–83, and it would be useless to repeat them here; but it will be well that the system should be explained.

78. It is impossible to frame workable Tables showing the exact lengths of true lunar months and tithis, because the length of each of these is perpetually changing. The moon's line of apsides makes a complete revolution every nine years, and in consequence her velocity in different years at the same sidereal point alters rapidly. The time-length of her synodical revolution also changes perpetually in consequence of the daily change in the velocity of the earth at different points of its orbit. And, in addition, her daily motion varies because her own orbit is elliptical. Our system, therefore, which follows that of Professor Jacobi in Vol. XVII. of the *Indian Antiquary*, is, as has already been explained, to obtain the true state of the moon at any moment by adding to our *a* (the mean longitudinal distance

of the moon from the sun) for that moment the equations, also for that moment, of the mean anomaly of the moon, *b*, and of the sun, *c*. This yields us the "true" position required.

79. To find the true tithi, therefore, for any moment we take down the *a, b, c* (*cols.* 19–21) at mean sunrise on the first civil day of the luni-solar year as given in Table I.; and we add to these the values of *a, b, c* for the interval of days, hours and minutes to the given moment (*Tables IV. and V.*). We add to the *a* of the quotient the amounts of equation *b* and equation *c* (*Tables VI. and VII.*), and thus arrive at *t*, or the tithi-index which (*Table VIII.*) gives us the apparent position of the moon at the given moment. Taking the figures in col. 3 of Table VIII. for the beginning and ending of the thus-found current tithi, and applying to them the value of the *t* we have obtained, we have the interval in terms of *t* between the given moment and the beginning and ending of the tithi. We turn this into mean time by Table X. This results in a first approximation. If we desire greater exactness we add or subtract, as the case may be (using Tables IV., V.), the *a, b, c* for the interval of time last found to or from the *a, b, c* already found for the given moment, and by again applying to the resulting *a* the equations of the resulting *b* and *c* we find the final *t*, which gives us the true tithi-index of the given moment. After one or two such operations we obtain in mean time (using Table X.) a result absolutely accurate so far as the system permits.

How to find the a, b, c for the first civil day of a year earlier than one in the period embraced by Table I. of the "Indian Calendar."

80. It is clear from what has been said that if we have given us, or capable of being found, the *a, b, c* of the starting-point, viz., at mean sunrise on the first civil day of the lunar year, all the rest is easy. Now Table I. (cols. 19–25) supplies this information for every year from A.D. 300 to 1900, but it does not contain the information for any earlier year, and we have to learn how this can be found.

81. It must first be observed, incidentally, that for many, especially the earlier, inscription-dates we have no certain knowledge of the authority by which they were calculated, and cannot therefore depend for practical work on any Tables yet published. The bulk of the present volume is concerned with the *Ārya* and *Sūrya Siddhāntas*, and the former did not come into use till after A.D. 500. Prior to that some other authority, possibly the *Original Sūrya Siddhānta* or another, was used for the preparation of almanacs. It may be possible hereafter to prepare Tables for these authorities, but at present all that we can do is to use the *First Ārya Siddhānta* as our authority, and ascertain the moon's position *as it would have been determined had that authority been the basis of calculation.*

82. The following process will enable the *a, b, c* of mean sunrise on the first civil day of a luni-solar year earlier than A.D. 300 to be found, according to the *Ārya Siddhānta*, from the *Indian Calendar* Tables and those in the present paper. When these values for *a, b, c* have been ascertained the rest of the work will proceed according to regular rule, the figures standing as if they belonged to cols. 19 to 25 of Table I.

83. We assume that the luni-solar year began astronomically with the new-moon next after the moment of the sidereal Mīna saṁkrānti, and that the first civil day of that year is the day on which the first tithi of the bright fortnight following that new-moon is current at sunrise. Having ascertained the facts on that theory it is easy to arrive at the correct result should the month have to be altered owing to the pūrṇimānta system of fortnights having been in use, or should the number of the year have to be altered because the solar year was taken to begin with any solar saṁkrānti other than that of Mēsha.

We must therefore first find the moment of Mēsha saṁkrānti for the given year. Let us take the year 155–4 B.C., K.Y. 2947 expired, as our example. (*For rule of work, see §§ 48–51 above.*)

577 — 155 = A.D. 422. Since therefore we know from Table I., cols. 13 to 17, that the Mēsha saṁkrānti of A.D. 422, K.Y. 3523 expired, occurred on March 18th (Saturday), at 4 h. 25 m. Laṅkā time, we also know that the moment of Mēsha saṁkrānti of our given year (K.Y. 2947 expired) occurred on Tuesday, March 13th, 155 B.C., at 4 h. 25 m. Laṅkā time.

Professor Jacobi (*Ind. Ant. XVII., pp.* 159, 160) has given the value of a, b, c for a difference of 5000 years, 1000 years, and 100 years. We take the 1000-year difference and work from a base already given us in Table I. of the *Indian Calendar*. The difference is $a = 4687.4$, $b = 500$, $c = 24.1$. The thousandth year from K.Y. 2947 expired is K.Y. 3947 expired. For this year Table I. (cols. 19 to 25) gives us the starting point.

	a.	b.	c.
Mean sunrise of March 2nd, A.D. 846 (K.Y. 3947)	9961	162	225
Interval of 1000 years	4687	500	24
Mean sunrise of March 2nd, 155 B.C. (K.Y. 2947) . . .	4648	662	249
(*Table VI.*) Equation b . . .	21		
(*Table VII.*) Equation c . . .	0		
$t =$	4669		

By Table VIII., col. 3, we find that the 15th śukla tithi was then current. We want the moment of the preceding new-moon; since a little calculation shows that at the Mēsha saṁkrānti of K.Y. 2947, which occurred eleven days later, the moon must be waning.[1] New-moon occurred about 15 days earlier. Find a, b, c for sunrise 15 days earlier.

	a.	b.	c.
Mean sunrise on March 2nd	4648	662	249
Interval of 15 days (Table IV.)	−5079	− 544	−41
Mean sunrise on February 15th	9569	118	208
Equation b	235		
Equation c	2		
$t =$	9806		

10,000 — 9806 = 194 =, by Table X., 7 h. 5 m. + 6 h. 40 m. = 13 h. 45 m., and we therefore know that, on a first approximation, new-moon occurred on February 15th, 155 B.C., K.Y. 2947 expired, at 13 h. 45 m. after mean sunrise. Hence the first civil day of the luni-solar year was February 16th, and for its a, b, c, at mean sunrise we add the value of a, b, c, for one day to the value obtained for mean sunrise of February 15th.

	a.	b.	c.
	9569	118	208
For 1 day (*Table IV.*)	339	36	3
	9908	154	211

[1] The actual interval was 11 d. 4 h. 25 m.

	a.	b.	c.
Mean sunrise of March 2nd	4648	662	249
11 days (*Table IV.*)	+3725	399	30
4 hours (*Table V.*)	+ 56	6	0
25 minutes (*Table V.*)	+ 6	1	0
	8435	68	279
Equation b . .	198		
Equation c . .	1		
	8634 = (*Table VIII.*) 11th krishna.		

The moon was waning at Mēsha saṁkrānti. The figure 279 for c proves that the date coincided with Mēsha saṁkrānti.

These then are the required values for sunrise of the first civil day of the luni-solar year beginning in 155 B.C.; and we work by them exactly as if those values had been entered in cols. 23 to 25 of Table I.

84. I have tested the values by working the same moment with the use of Professor Jacobi's *Indian Antiquary* Tables, his Table 6 being extended backwards to a distance of 20 centuries from the 19th century, and using in his Table 5 the year A.D. 1846, which is the proper one to take for a year 55 or 155 B.C. The result is precisely the same, namely, for mean sunrise on March 2nd, 155 B.C., $a = 4648$, $b = 662$, $c = 249$. (*See Tables XXXIX., XL., below.*)

85. But the warning cannot too often be repeated—these figures only show the results of calculation by the *First Ārya Siddhānta*, which was not composed for over six centuries after the date in question. What was the exact day and hour of the occurrence of new moon according to any other authority in use at the time it is not as yet possible to say. It is however not improbable that the result, in the matter of the state of the moon on the day in question, is fairly accurate, for reasons that need not now be gone into.

Professor Jacobi's "Indian Antiquary," Tables 5, 6.

Vol. XVII. pp. 163, 164.

85A. Since it is often exceedingly useful, and even necessary, to check the accuracy of calculations made for the *a, b, c* of mean sunrise of any day by the method suggested in the text (*above*, § 84), and in general for all luni-solar dates, I have framed Tables XXXIX. and XL. in order to enable this to be done. They are based on Tables 6 and 5, respectively, of Professor Jacobi's treatise in the *Indian Antiquary*, Vol. XVII., on the "*Methods and Tables for verifying Hindū dates.*"

85B. Table XXXIX. consists of the Professor's Table 6 taken without alteration; except that his last column is omitted, columns are added showing, throughout, the years for which the entries are to be used, and the calculations are carried back for 23 centuries, or eight centuries earlier than the entries in Table 6. This enables the Table to be used for any year from 500 B.C. downwards. At the end, seeing that the New Style was introduced into Europe at different times from A.D. 1582, I have given the figures for both styles from A.D. 1500 to 2000.

That no mistake may be made in using this Table from the years A.D. 1582 to 1752 I repeat here the note in the *Indian Calendar*, p. 103. The New Style was introduced into all the Roman Catholic countries in Europe from October 5th, 1582, the year 1600 remaining a leap-year; while it was ordained that 1700, 1800 and 1900 should be common and not leap-years. This was not introduced into England till September 3rd, A.D. 1752.

85C. This Table has always to be used in conjunction with the Professor's Table 5, which gives the *a, b, c* for odd years of a century, and with Table 7, which gives the *a, b, c* for the days of any month in the year. The three Tables, worked together, enable us to find the *a, b, c* for mean sunrise of any day of any year. But the entries in his Table 6 were limited to a period of 15 centuries earlier than the 19th century A.D., and, now that I have carried this back to 23 centuries earlier than the 19th century A.D., it is necessary to adapt Table 5 so as to suit the odd years of any century B.C. as well as those of the period A.D. This is now done in my Table XL. And, by the use of my Table XXXIX., Jacobi's Table 5 (taking, as given in my Table XL., for the odd years of a century B.C., the figures for the years quoted by him of the 19th century) and Jacobi's Table 7, we can now calculate the *a, b, c*, and find thereby the moon's place, both true and mean, at mean sunrise of any day from A.D. 1900 back to January 1st, 500 B.C. The Tables apply, for luni-solar calculation, to all the Siddhāntas.

85D. Thus in § 83 I showed, according to one method of calculation, that for mean sunrise on March 2nd, 155 B.C., the values for *a, b, c* were respectively 4648, 662 and 249; and in § 84 I stated

that I had proved this to be correct by using Professor Jacobi's Tables. I now proceed to set forth this latter proof in Jacobi's figures, with the aid of Tables XXXIX., XL. The year is 155 B.C., and we use (*Table XXXIX.*) the century figures for 200 to 101 B.C. For the odd year 55 we use the figures given in Jacobi's Table 5 for 1846 (*see Table XL.*). And for March 2nd we use his Table 7. The year was a common one, not a leap-year.

	w.	*a.*	*b.*	*c.*
(*Table XXXIX.*) B.C. century 200–101	4	3438	430	81
(*Table XL. and Jacobi's Table* 5) odd year 55	5	892	55	4
(*Jacobi's Table* 7) March 2nd	4	318	177	164
At sunrise on Friday, March 2nd, 155 B.C.	6	4648	662	249

These results are exactly the same as those obtained by my own method (founded, as stated in § 83, on Professor Jacobi's data), which are thus proved correct. The day of the week can be further proved by reference to Table XLI. A, B.

85E. Table XXXIX. can be carried back to any distance of time by adding for every century the differences of *a*, *b* and *c* (respectively per century 1468.7, 450, and 2.4) to the figures for 500–401 B.C.; which figures, calculating those for the last century of the Julian Calendar given by Jacobi, viz.: A.D. 1501–1600, as whole figures, are themselves whole figures, *i.e.*, without decimals.

Adhika and kshaya tithis.

86. A tithi on which the sun does not rise is expunged. A tithi on which the sun rises twice is repeated. The first is called a *kshaya* tithi, "diminished" or "lost." The second is called an *adhika*, "added," tithi. In the case of a kshaya tithi the day on which it begins and ends is its week-day. In the case of an adhika tithi both the days at whose sunrise it is current are its week-days. Turning to the Pañchāṅg, or almanack, extract given on pp. 14, 15 of the *Indian Calendar*, we see that the 7th tithi of the dark half of the month was kshaya. It began and ended on Friday, and therefore that Friday is its week-day. The 13th tithi of the bright half was adhika. It was current at sunrise on both Wednesday and Thursday, and both Wednesday and Thursday were its week-days.

A full description of these tithis is given in § 32, pp. 17, 18, of the *Ind. Cal.* (*See also* § 142, *p.* 78, *and below, Hints* 16.)

87. But this rule appears to me to require a little more comment than has hitherto been bestowed upon it. Professor Jacobi (*Ind. Ant. XVII.*, 146, *Epig. Ind. I.*, 405) explained the matter more fully, and in my opinion better, than we did in the *Indian Calendar*, but the explanation still needs some slight expansion to ensure its being thoroughly understood. It might be imagined, from the expressions "repeated" and "expunged" with reference to a tithi, that the tithi itself is repeated or expunged, but this is not the case. For instance, in the Pañchāṅg extract above alluded to it will be noticed that in the first half of the month under consideration there were 16 civil days, and in the second half only 14 civil days, or rather there were 16 sunrises in the first half and 14 in the second. But that does not mean that there were 16 *tithis* in the first half and 14 *tithis* in the second. The tithis follow one another in regular order. The repetition or expunction of a tithi is only with reference to the *number given to the civil day*. The practice of the Hindū calendar as regulated by true time has always been to give to each civil day the number of the tithi current at sunrise, the civil day being measured from sunrise to sunrise. But if a tithi, in consequence of its length being greater than that of the interval between the sunrises and of its commencement occurring very shortly before the first sunrise, is current at two successive sunrises, then, having been current at the first, it gives its name and number to the first of the civil days concerned; and having been current at, or ending after, the second, it also gives its name

and number to the second civil day. In other words, it is repeated. But the tithi *itself*, as a tithi, runs its natural course, and is not repeated. Similarly if a tithi, in consequence of its length being less than the interval between two sunrises and its commencement occurring very shortly after the first sunrise, is not current at either sunrise, but falls altogether between two successive sunrises; then, since the first of the two civil days concerned bears the name and number of the next preceding tithi and the second of the two bears the name and number of the next following tithi, the tithi in question confers its name and number on no civil day. In other words it is expunged from the point of view of civil days. But the tithi itself runs its natural course and is not expunged.

88. The repetition and expunction of tithis then does not affect the tithis themselves, but refers to the tithi-number and name conferred on the civil day with which it is connected.

89. Consequently karaṇas, which are half-tithis, follow one another always in regular order, and since the tithi *itself* is never repeated or expunged there is no repetition or expunction of karaṇas.

Computation by mean lunar months and tithis.

90. A true synodical new-moon takes place when, with reference to her and the sun's true position, *i.e.*, taking into account the lunar and solar equations (equation *b* and equation *c*), the centres of the moon and sun are in the same plane with the earth. If the three are in the same straight line a total eclipse of the sun takes place. A mean synodical new-moon occurs when, without any reference to the moon's or the sun's true position, *i.e.*, leaving out of account the lunar and solar equations, the distance of the moon from the sun in mean longitude is nil. A mean synodical lunar month measures 29 d. 12 h. 44 m. A true synodical lunar month varies in length from 29 d. 7 h. 20 m. to 29 d. 19 h. 30 m. There is therefore very often a considerable difference between the moments of true new-moon and mean new-moon. A mean tithi is one-thirtieth of a mean lunation, or 23 h. 37 m. 28.093 s. In calculating with our Tables by mean lunar months and tithis we find the position of the mean moon from our *a* alone, which, when increased by the constant 201 as explained above (§ 20), gives us the distance of the moon from the sun in mean longitude; and this is all that we have to consider in such computations. Table I., cols. 19, 20, 23, and Table XXI. enable this to be done.

91. I assume that calculation by mean lunar months and tithis had for its starting point the moment of that mean new-moon which marked the astronomical beginning of the luni-solar year, just as in calculation by true lunar months and tithis the moment of true new-moon is the starting point. An example from an actual inscription-date will best illustrate the method of work. We are given as date Sunday, the 1st śukla tithi of Pausha in K.Y. 4090 expired, A.D. 989-90.

92. Turning to Table I., cols. 19, 20, 23, we find that at mean sunrise on the first civil day of Chaitra in that year, viz., on March 11th, A.D. 989, the 70th day and a Monday, $a = 93$, or 93 lunation-parts had elapsed since new-moon. Add the constant 201. Then the actual $a = 294$. This, in mean time, is (*Table X.*) 14 h. 10 m. + 6 h. 40 m., total 20 h. 50 m. Approximately therefore mean new-moon took place 20 h. 50 m. before mean sunrise on March 11th, or on (1) Sunday, March 10th, the 69th day, at 3 h. 10 m. Lankā time. Interval to mean new-moon of Pausha, which is the beginning-point of the given tithi (*Table XXI.*) = 265 d. 18 h. 36 m., with 6 week-days.

d.	*w.*	*h.*	*m.*
69	(1)	3	10
265	(6)	18	36
334	(0)	21	46

334 = (*Table IX.*), November 30th. (0) = Saturday. The mean new-moon of Pausha occurred at 21 h. 46 m. after mean sunrise of Saturday, November 30th, A.D. 989, or 2 h. 14 m. before sunrise of

Sunday, December 1st, on which day at sunrise the 1st śukla tithi was current. The inscription therefore may be considered as correct when computed by mean lunar months.

Another, and perhaps easier, way of work for mean lunar months is, after finding the *a* of mean sunrise on Chaitra śukla 1st of the year in question, with its *d* and *w*, to add from Table IV. the *d*, *w*, and *a* of the days intervening to mean sunrise on the given day, and thus to find the *a* of the latter. Thus, in the instance just considered, we had, for mean sunrise on Chaitra śukla 1st, *a* = 294. The interval to mean sunrise of Pausha śukla 1st is 265 days.

	d.	*w.*	*a.*
For Chaitra śuk. 1	(70)	2	294
For 265 days (*Table IV.*)	(265)	6	9737
	(335)	1	31

(335) =, by Table IX., December 1st. 1 = Sunday. 31 =, by Table X., 2 h. 12 m. And this shows that the mean new-moon of Pausha occurred 2 h. 12 m. before mean sunrise on Sunday, December 1st, A.D. 989. The difference between the two methods is only 2 m.; the former method being the more accurate of the two.

93. Calculation by true lunar months and tithis was made for this date by the late Professor Kielhorn (*Epig. Ind. IX.*, 207, *No.* 137), and he informs us that the true 1st śukla tithi of Pausha began, *i.e.*, true new-moon occurred, at 5 h. 6 m. *after* mean sunrise on Sunday, December 1st. If so it would appear that very probably calculation had been made by mean lunar months, since, in that case, Sunday, December 1st, would have been rightly coupled with the first śukla tithi. The tithi current according to calculation by true months at sunrise on that day was the last tithi of the previous month Mārgaśīrsha, and in ordinary circumstances *that* tithi would have been coupled with the Sunday.

Intercalations and suppressions of lunar months.—True and mean systems.

95. (*See Indian Calendar*, §§ 45, 46, *pp.* 25 to 27.) The length of a true solar month varies from, by the *Sūrya Siddhānta*, 29 d. 7 h. 38 m. to 31 d. 15 h. 28 m., and by the *Ārya Siddhānta* from 29 d. 8 h. 25 m. to 31 d. 14 h. 34 m. The length of the true synodic lunar month, new-moon to new-moon, varies from 29 d. 7 h. 20 m. to 29 d. 19 h. 30 m. Consequently it happens, roughly about once in every two or three years, that during a whole lunar month there is no saṁkrānti, and more rarely a lunar month in which there are two saṁkrāntis. Since ordinarily each of the twelve lunar months ends after each of the solar saṁkrāntis, a lunar month in which there is no saṁkrānti has to be repeated, or intercalated, and then, the second of these months ending after its proper saṁkrānti, the rotation of months continues as before. The first of the pair of months is called *adhika* ("added") and the second *nija* (or "true"). When there are two saṁkrāntis in the lunar month the name of a lunar month is suppressed, because from the point of view of the rotation of months it is superfluous; since the new-moon at the end of that month ends next after two saṁkrāntis instead of after only one. It is in this sense that there is said to be a "suppressed month," *i.e.*, the name of one month is omitted. Such a suppressed month is called a *kshaya māsa*.

96. As to the naming of adhika and kshaya months there is a divergence in practice on which it is not necessary here to enter. I confine myself to the ordinary nomenclature, which calls the first (added) month *adhika*, "added," or *prathama* ("first"), and the second *nija*, "true," or *dvitīya* ("second"). And I shall not deal with the different ways of naming pūrṇimānta months. The system of work for calculating these is always the same; the only difference being in the names. But in examining dates these different practices must always be borne in mind lest a genuine date should be unjustly condemned because the name of the given month differs from that found by the ordinary system. A full discussion of the matter will be found in the *Indian Calendar* (pp. 25–31).

97. Intercalations and suppressions have since, it is believed, about A.D. 1100, been always regulated by the sun's and moon's true motions. Prior to the 10th century A.D. it is probable that the calculation was generally by mean motions. In the *Vēdāṅga Jyōtisha* (about 1400 B.C.) no account is taken of the true motions of the sun and moon. Mean intercalations seem not to have been known in the time of Bhāskarāchārya (A.D. 1150). But in some parts of India at least the true or "apparent" system was used as early as the *beginning* of the 10th century A.D. (*Above*, § 32.) The systems are known as the "true system" and the "mean system." For purposes of our calculations it is necessary, when working by the true system, to add to a the equations of b and c, the result, t, showing the moon's age at the moment of the saṁkrānti; but in the mean system no account is taken of b and c, the a alone, when increased by 201 (§§ 20, 21), showing the correct age of the moon at the saṁkrānti. When we find the moon's age at the saṁkrānti near to but less than 10,000 (the moment of new-moon) we know that the moment of new-moon was after the saṁkrānti (*e.g.*, the unit of t being 4.25 m., $t = 9996$ at the saṁkrānti shows that the moment of new-moon was ($t = 4 =$) 17 m. after the saṁkrānti); and when we find the moon's age at the saṁkrānti to be near to but greater than 0 (the moment of new-moon) we know that new-moon took place before the saṁkrānti (*e.g.*, $t = 4$ shows that the new-moon took place 17 m. before the saṁkrānti). Consequently when, working the t for two consecutive saṁkrāntis, we find t approaching 10,000 at the first, and only slightly exceeding 0 at the last, we know that no saṁkrānti occurred in that lunar month which lay between the two, and therefore that that lunar month was intercalated (*adhika*).

98. And similarly when we find t near to but greater than 0 at one saṁkrānti, and near to but less than 10,000 at the next, we know that two saṁkrāntis occurred during the lunar month, and therefore that it is suppressed (*kshaya*). (*See especially* § 50, *pp.* 29, 30, *Ind. Cal., and* "*Hints,*" *Nos.* 8, 9, 12–14, 18 *below*.) The same is of course the case with the figures for a in calculations by the mean system.

99. Tables XVIII.A and XVIII.B are for work by the true system, and show the collective duration and the increase of a, b, c from Mēsha saṁkrānti[1] for each of the sidereal saṁkrāntis, as well as the individual lengths of solar months between saṁkrāntis, by the *Ārya Siddhānta* and *Sūrya Siddhānta* respectively; Table XVIII.C gives the figures to be used when converting a result by one into a result by the other of the two Siddhāntas. And Tables XIX.A and XIX.B are for work by the mean system similarly. There is no appreciable difference between these last two.

100. In practical work values of vipalas and seconds may be ignored, fractions over half being taken as one pala or one second respectively. (*See also* "*Hint*" *No.* 20 *below*.)

101. The general principles governing *mean intercalations* are similar to those for true or apparent intercalary months; but mean saṁkrāntis have to be calculated from the moment of mean, not true, Mēsha saṁkrānti (for the method of finding the moment of mean Mēsha saṁkrānti, *see* "Correction III." § 57 above); and we have to work by mean, not true, length of solar months. This done, the moon's place is found in the usual way, the $a + 201$ alone being taken into consideration; in other words, we deal with the moon's mean longitude alone, without reference to the mean anomalies of moon (b) and sun (c). For actual practice, see Examples 36 to 39 below.

102. A lunar month is, as above stated, *suppressed* whenever two saṁkrāntis occur in it. This requires the combination of a long lunar month with a short solar one. The short solar months are between the Vṛiśchika and Mīna saṁkrāntis (*see Tables XVIII.A or XVIII.B, cols.* 6 *or* 7), and these are connected with (*col.* 1) the lunar months Mārgaśīrsha, Pausha, Māgha and Phālguna. The first two of these are the months most commonly suppressed. (See Examples 29, 32 below.)

[1] It makes no difference whether we begin calculation for intercalation and suppression of the lunar months at true Mīna saṁkrānti and thence find the moment of the following new-moon, or at true Mēsha saṁkrānti and thence find the moment of the preceding new-moon; except in years in which the first month, Chaitra, is itself intercalary. I recommend beginning with Mēsha saṁkrānti because the day and hour of its occurrence are given in Tables I. and XXXVIII.A and B; and this forms a convenient starting-point.

103. Note that whenever a number of separately stated values for increase of *a*, *b*, *c* have to be added together there is always a danger of slight error in the total, because, fractions below half being omitted, each separate increase may be a fraction too high or too low. But as a general rule one error rectifies another. In the case of mean intercalations six separately stated values of *a*, *b*, *c* have to be added together, and the possibility of error should be remembered when the resulting totals are very near 10,000 or 0 respectively. For these reasons I find that my results for mean intercalations often differ by one or two units from those obtained by Sh. B. Dikshit.[1] He wrote to me at the end of 1893 that he had invented a method by which the working was very easy (it was probably the same, or nearly the same, as Prof. Jacobi's in *Epig. Ind. I.*, 418, § 35), the figures being obtained direct in tithis and decimals, and converted into the tithi-index (*t*) by division by 30. I cannot say which method is least liable to error; possibly his, but I have tested a number of cases and find the difference between us very slight, so that my system may, I am satisfied, be depended upon as sufficiently accurate for all practical purposes. Close cases must always be carefully examined by Prof. Jacobi's "Special Tables."

N.B.

Conversion of results obtained by the Ārya Siddhānta into results by the Sūrya Siddhānta, and vice versa.

104. In this publication I am dealing principally with the *First Ārya* and *Present Sūrya Siddhānta*. It would be impossible to give rules for the conversion of results by one authority into the same by another according to the "true" system, unless we knew the exact lengths of true or apparent months as fixed by each; and this we do know for the two Siddhāntas mentioned, but not, I believe, for any other. Results by the mean system could, however, be easily converted, each mean month being exactly one-twelfth of the fixed year-length in each case. Amongst the Tables below will be found a list of these year-lengths, so far as I have been able to gather them. (*Table* XXXVII., *col.* 3.)

A. *The true or apparent system.*

105. The causes of difference between results arrived at by using the *First Ārya* or the *Present Sūrya Siddhānta* respectively are, so far as the "true" system is concerned in which calculations are made by the true or apparent motions of the sun and moon, (1) the different lengths of the sidereal year ("*Correction I.*" § 46 *above*), and (2) the different lengths of the true solar months as fixed by each ("*Correction II.*" § 55). The figures to be applied are given in Tables XVII. and XVIII.C.

106. It will however be noticed that, whereas these correction-Tables can always be applied direct when a result for which conversion is desired stands expressed in time or in terms of *a*, *b*, *c*, this is not quite the case when we wish to convert a result expressed in terms of *t*, as in cols. 9 and 11 of Table I. where the times of true saṁkrāntis are given according to the *Sūrya Siddhānta*. For such cases we still use Table XVIII.C, and apply to the given *t* the value of *a* contained in it, ignoring the values of *b* and *c*; but the result is only approximate. The reason for this is as follows.

107. In every calculation on the *a*, *b*, *c* system the desired result *t* is obtained by adding to the given *a*, not the given *b* and the given *c*, but the *equation* of *b* and the *equation* of *c*. Now in Table XVII., for Correction I., the highest value of *b*, even for a year removed 1400 years from the base-year, is only 4; and *c* never suffers any change. In Table XVIII.C, for Correction II., the value of *c* again suffers no change; and therefore both under Tables XVII. and XVIII.C, if preferred, *c* and its equation may be altogether ignored. As regards *b* in Table XVIII.C the greatest difference is 3, for the Karka, Siṁha, and Kanyā saṁkrāntis. It is 2 for the Tulā saṁkrānti, 1 for five others, and 0 for three. Taking the greatest difference, 3, and turning to Table VI., *Ind. Cal.*, it will be observed that *equation b* (which alone affects the ultimate result) for the value $b = 3$, though it may be itself 3 in certain positions of

[1] The figures given in cols. 9A to 12A of Table I. in the *Indian Calendar* are those fixed by Mr. Sh. B. Dikshit.

the moon, as when the moon's mean anomaly *b* stands between 0 and 45, or 455 and 555, or 955 and 1000, would only amount to 2 in certain other positions, or to 1 in others. These values of equation *b* may be additive or subtractive according as the equation was increasing or decreasing at the time. It would be easy for anyone to reduce these possible changes in *t* under the two corrections to a Table, but perhaps it is safer at present to deal with the greatest possible differences that can exist, and to say that it is *possible*, for the period embraced by our Tables, for the change in equation *b*, at certain saṁkrāntis and in certain positions of the moon, to amount to + 3 or — 3, in Table XVIII.C. Total difference 6.

108. With this reservation we convert the given *t* from one Siddhānta to the other by applying to it the values of *a* given in Tables XVII. and XVIII.C, and we remember that under Correction II. (*Table XVIII.C*) it is possible that the result may be wrong by (*t* =) 6, or 4, or 2, according to the saṁkrānti concerned and the condition of the moon (6 = 26 m., 4 = 17 m., 2 = 9 m.); while under Correction I. (*Table XVII.*) we may be wrong by (*t* =) 1, 2, 3 or 4, according to the interval between the base-year A.D. 496 and the given year, the amount of our error increasing with the amount of interval.

109. If, of course, we have the *a, b, c* of the result to be converted, and not, as thus presumed, the *t* only, we get absolutely correct results under the true system, by applying to that *a, b, c* the *a, b, c* of the two necessary corrections (XVII. and XVIII.C).

110. As an example I have worked out the details for the true intercalation of Bhādrapada in K.Y. 4343 expired, A.D. 1242–3. The two saṁkrāntis concerned were Siṁha and Kanyā. By the *Ārya Siddhānta* for the Siṁha saṁkrānti of that year the resulting figures were *a* = 9701, *b* = 737, *c* = 622, and for the Kanyā saṁkrānti *a* = 211, *b* = 863, *c* = 707. The conversion figures for Siṁha (Tables XVII. and XVIII.C) are respectively (+) *a* = 19, *b* = 3, *c* = 0, and (+) *a* = 25, *b* = 3, *c* = 0; and for Kanyā are (+) *a* = 19, *b* = 3, *c* = 0, and (+) *a* = 20, *b* = 3, *c* = 0. This gives us result by the *Sūrya Siddhānta* for the Siṁha saṁkrānti *a* = 9745, *b* = 743, *c* = 622, which result gives *t* = 9848; and for the Kanyā saṁkrānti *a* = 250, *b* = 869, *c* = 707, which result gives *t* = 406. These last are the exact figures as printed in Table I., p. lx.

Now by the *Ārya Siddhānta* the *t* for Siṁha was 9804 and the *t* for Kanyā was 364. If, therefore, we convert these to *Sūrya Siddhānta* results by only adding, as suggested above, the *a* of Correction I. (*Table XVII.*) and the *a* of Correction II. (*Table XVIII.C*), and ignore the *b* and *c*, we have to add respectively (*a* =) 44 and (*a* =) 39, and we have for *Sūrya Siddhānta* results (*t* =) 9848 and 403 for the two saṁkrāntis. The former was correct, but there is an error of (*t* =) 3 in the latter.

Still, as stated, the error is limited, and unless the moment of new moon happens to be very close to the moment of the saṁkrānti we may be satisfied that the same lunar month was intercalated or suppressed by both the Siddhāntas concerned. (*See Examples* 33 *to* 35 *below.*)

111. In the case of mean intercalations and suppressions the conversion of results by one into results by the other of the two Siddhāntas is extremely easy. A full explanation was given above under the head "Correction III.," and it need not be repeated. It will be sufficient here to say that in calculations for mean months a result obtained according to one authority is converted to a result according to the other by using Corrections I. and III., as given in Tables XVII. and XIX.A or XIX.B. (*See Examples* 40, 41, *below.*)

B. *The mean system.*

NAKSHATRAS, YŌGAS AND KARAṆAS.

112. For an explanation of these see the *Indian Calendar*, §§ 8, 9, 10, p. 3; §§ 38–40, pp. 21–23; §§ 43, 44, pp. 24, 25; §§ 131–133, pp. 64, 65; and for method of calculation §§ 153–159, pp. 96–98.

113. The constant and regular motion of the moon along a path in the heavens among the fixed stars once in every month was a phenomenon that forced itself on the notice of Hindū observers from the earliest ages; and they divided the belt through which she passed into twenty-seven parts called "nakshatras," which corresponded roughly to the twenty-seven and one-third days of her sidereal revolution. These were named after the principal stars or groups of stars lying along, or near to, that belt. But the distance of these groups from one another was seen to be unequal, and different systems were adopted for dividing the 360° of the circle. By the system of Garga, fifteen of the nakshatras are of equal length, viz. 13° 20′, six measure one and a half of this length, viz. 20°, and six measure half a length, or 6° 40′. Another division was adopted by Brahmagupta in his *Brāhma Siddhānta* (composed in the year A.D. 628). He maintained the unequal division of the belt, but grounded his measurement on the 13° 10′ 35″ of the moon's daily mean motion instead of 13° 20′, allotting to fifteen nakshatras 13° 10′ 35″ each, to six 19° 45′ 52½″ each, or 1½ times, and to six 6° 35′ 17½″ each, or one-half. Twenty-seven of these amounting to 355° 45′ 45″, the remainder 4° 14′ 15″ is allotted to a twenty-eighth nakshatra called "Abhijit." One of these systems was certainly in use as late as A.D. 862, as is proved by the Dēōgaḍh inscription of Bhōjadēva of Kanauj (*Fleet and Sh. B. Dikshit, Ind. Ant. XVII.*, 4, 23, 24; *Kielhorn, ibid., XIX., p.* 28, *No.* 30), but how much later and in what tracts is not yet known. The third system of division is called the "equal-space" division, according to which the whole belt of 360° is divided into twenty-seven equal parts, each measuring 13° 20′. This system sometimes, but not always, recognises the existence of the nakshatra Abhijit, but in doing so includes it as contained in parts of the nakshatras Uttarā Ashāḍhā and Śravaṇa.[1]

Nakshatras.

114. The first nakshatra of the cycle, Aśvinī, begins at the first point of the sidereal sign Mēsha.[2] It ends, and the second begins, by the equal-space system and that of Garga, at 13° 20′, and by the *Brāhma Siddhānta* at 13° 10′ 35″; the rest in succession. The sun, the moon and the earth's meridian traverse the whole round of nakshatras, the first annually, the second monthly, the third daily; and this gives rise to a number of different chronometric calculations for calendrical and astrological purposes. Thus the sun's position in a nakshatra is often calculated, as well as his position in a zodiacal sign; the nakshatra in which the moon stands at sunrise of each day is one of the most important elements in the Southern calendar, and has been noted and calculated from very ancient times; and, since the earth's rotation brings a meridian round to every point of the heavens, roughly, once in each day,[3] the time of day when each sign or nakshatra rises on the eastern horizon is calculated. At this moment of rising the particular point of the ecliptic is said to be *lagna*, "intersecting," "in contact with" the horizon.[4]

115. The nakshatras were used for purposes of dates certainly as early as the 4th century A.D. The Singhalese chronicle, the *Dīpavaṁsa*, which came to an end about the middle of that century, mentions the nakshatra current at the time of the first anointment of King Dēvānaṁpiya Tissa. It describes the event as taking place "in the season Hēmanta in the second month when the moon was in the Ashādhā nakshatra." (*J. R. A. S., Jan.* 1909, *p.* 11, *n.* 2.) But as yet it is impossible to fix any date as that when the use of nakshatras began to be adopted in India for ordinary calendrical purposes. For astrological purposes they were known in late Vedic times. The *Kauśika Sūtra* of the *Atharva*

[1] I am not sufficiently learned to pronounce any opinion as to which of these three systems was the earliest and which latest. Dr. Fleet (*Ind. Ant.*, XXXIX., 1910, *p.* 255) believes that the equal-space system was the oldest, since it is used in the *Vēdānga Jyōtisha*, the earliest known Hindū astronomical work; then that of Garga; lastly that of Brahmagupta (A.D. 628–29).

[2] This point is sometimes called the "first point of Mēsha" and sometimes the "first point of Aśvinī."

[3] *I.e.*, once in every sidereal day, which is four minutes less than a civil day.

[4] The ecliptic-point becomes *kshitijē-lagna* when it touches the eastern horizon, and *madhya-lagna* when it touches the meridian. The former is most commonly used. Each point on the ecliptic belongs to one of the signs and one of the nakshatras, and therefore at every moment of every day some sign or some nakshatra is *lagna*.

Vēda contains a *Nakshatra-kalpa* and a *Śānti-kalpa*, both treating of the lunar mansions. (*A. Weber. Hist. of Indian Liter.* 1878, *pp.* 152–3.) They do not seem to have been in universal use for recording dates in all parts of India. Only one among the known inscriptions of the Gupta series, viz. that of Mānadēva of A.D. 705 mentions a nakshatra ; and the majority of early dates found in the tracts where the lunar calendar was generally in use omit mention of them. But they are often stated and were regularly used in South India, from at least as early as the 10th century A.D., where they form one of the most important elements of the date, each day being named after the nakshatra current at sunrise. Mr. Sh. B. Dikshit believed that the nakshatras were, as early as 2000 B.C.,[1] so well known that the names of the lunar months now in current use were, about that period, derived from them.

116. This derivation is indisputable. The ancient names of the lunar months were connected with the seasons, such as "hot," "rainy," "vapoury," and so on (which implies that the reckoning was luni-solar and not purely lunar).[2] Afterwards the full-moon tithi (*pūrṇimā*) on which the moon became full when near the nakshatra Chitrā was called *Chaitrī*, and the lunar month which contained the *Chaitrī pūrṇimā* was called *Chaitra ;* and so on. (*Ind. Cal.*, §§ 41–44, *pp.* 24, 25, *and Table.*)

117. The sun's position with reference to the nakshatras is occasionally mentioned in inscriptions, though this could of course only be a matter of calculation and not of observation ; but the solar months were, in most parts of India except the Tamil country, named formerly after the nakshatras, the zodiacal sign-names succeeding them.

118. The correspondence of the zodiacal signs with the nakshatras is exhibited in Table XXII., which was prepared, for the equal-space system and that of Garga, by Dr. Fleet, and for the *Brāhma Siddhānta* by myself. The ending-points of the nakshatras were also stated in the Table on p. 22 of the *Indian Calendar* in degrees, minutes and seconds ; and for practical work by the a, b, c system in terms of t (the tithi-index) in Table VIII.

119. The moon's nakshatra, which is considered as an *observed* fact, is found from her apparent longitude, and our process of work for this is fully described in *Ind. Cal.*, § 133, pp. 64, 65 ; while the practical and very simple method of actual work is given in §§ 156–158, p. 97. It amounts simply to this—In every process of work by the a, b, c system for finding the lunar tithi current at a given moment, we have to fix the values at that moment of c (the sun's mean anomaly), equation c, and t the finally found tithi-index. n being the nakshatra-index required (which gives us the moon's apparent longitude, and therefore her position with reference to the fixed stars of the nakshatra-belt) the formula is—

$$n = (c \times 10) + 7207 - \text{equation } c + t$$

Thus, in the example given on p. 81 of the *Indian Calendar*, $c = 439$, equation $c = 38$, $t = 1463$, and the work is—

$$\begin{array}{r} 4390 \\ +\ \underline{7207} \\ 1597 \\ -\ \underline{38} \\ 1559 \\ +\ \underline{1463} \\ 3022 \end{array}$$

(*See also Ind. Cal.*, *p.* 97.)

The portion of the formula which gives the apparent longitude of the sun is $(c \times 10) + 7207 -$ equation c, and calling this s we have $n = s + t$. Though the formula is exceedingly simple, Dr. Schram has made

[1] "Certainly not later than 1500 B.C. and not earlier than 4000 B.C." (S. B. D., *Ind. Cal.*, . 24, n.)

[2] The old names were occasionally used to a much later date, *e.g.*, in A.D. 437–8, 473–4, in the Mandasōr Gupta inscription. (*Fleet, Gupta Inscriptions*, p. 79.)

it even easier by providing a Table by which *s* can be found at once from the *c* of the given moment. This was first published in the *Indian Antiquary* (1896, *pp.* 287–88), republished in my *Eclipses of the Moon in India* (*pp.* 10, 11), and by his kind permission I again republish it as Table XXIII. below for general use by those who prefer it. Properly used it yields the same result as is obtained from the method stated above. Thus in the above example Table XXIII. gives, for argument *c* 430, 1473. Add 86, for difference of *s* with last figure 9, by the auxiliary Table. Total *s* = 1559 as above. With the *n* so found we turn to Table VIII. where cols. 7 to 10 give the ending-points of the several nakshatras by the three systems. Our *n* gives us the state of the nakshatra-index at mean sunrise on the day in question, and we take the difference between its value and the value for the beginning and ending of the nakshatra (*Table VIII.*), and so find the resulting argument, which we turn into mean time by Table X. (*See the concluding paras. of* § 158, *p.* 97, *Ind. Cal.*) This gives us, in mean time, the beginning and ending times of the nakshatra.

120. Both these systems entail an unavoidable possibility of error consequent on the multiplication of *c* by 10, an error which may amount to as much as 42 minutes in some cases, but never more than that. This multiplication is necessary in order that the value of *c*, which is expressed in thousandths of the circle, may conform to the value of *t*, which is expressed in ten thousandths. By Prof. Jacobi's *Special Tables*, where the work is carried out in degrees, minutes and seconds, this error is reduced to 15 minutes, his *n* being obtained by multiplying his tithi (with two places of decimals) by 12 in order to obtain degrees and decimals.

121. I have taken great pains to ascertain the system of nakshatra calculation adopted by the late Prof. Kielhorn, whose figures for the nakshatra I found constantly to differ from mine and from Prof. Jacobi's by a few minutes. He appears to have followed our *Indian Calendar* method, but with a difference. Having observed that because of our multiplication of *c* by 10 the difference of one unit in *c* causes a leap in *c* × 10 of 10, or 42 minutes, for each unit so multiplied—which leap is modified by the changing values of equation *c*, which is the quantity actually added—he stated the ending-point of the current nakshatra not in, as we do, the mean-time equivalent (*Table X.*) of the ending-point (*Table VIII.*) minus our final value of *n*, but in the mean-time equivalent of the nearest figure to this, with the last unit ignored. He habitually, that is, gave the mean-time equivalents of 10, 20, 30, &c., and their multiples, as the ending-points of the nakshatra, and never stated the mean-time equivalents of 11, 12, 13, &c. Supposing, for instance, that we have a series of ending-times of nakshatras in different inscription-dates resulting from (*Table X.*) arguments 1, 2, 3, &c., up to 20. According to Table X. the ending-times would be respectively 4 m., 8 m., 12 m., &c., up to 1 h. 11 m., 1 h. 15 m., 1 h. 19 m. Now the time-equivalents for arguments 10 and 20 are 39 m. and 1 h. 19 m., and Prof. Kielhorn's plan was, for all ending-times between 0 m. and 1 h. 19 m., to state the result as either 0 m. or 39 m. or 1 h. 19 m.; and so for all values, advancing by the equivalents of tens instead of units in the argument.

122. Some examples will best illustrate Prof. Kielhorn's method.

(*Ep. Ind. VIII.*, 278) Pāṇḍya date 51. By the *Ind. Cal.* system the nakshatra ended at 14 h. 14 m., the argument (*n*) being (*Table X.*) 217. Kielhorn stated the ending-time at 14 h. 27 m., as if with argument 220; this by the equal-space system. According to Garga the argument was 32 and the ending 2 h. 6 m. Kielhorn quoted this ending as 2 h. 38 m. as if with argument 40.

(*Ep. Ind. IX.*, 211–12) Chōḷa date 147. With the *Ind. Cal.* system the ending (Garga) was 2 h. 14 m., with argument 34. Kielhorn gave it, as if with argument 40, at 2 h. 38 m.

(*Ep. Ind. IV.*, 262.) Chōḷa date 20. By the *Ind. Cal.* system (equal-space) the ending was, with argument 45, 2 h. 57 m. Kielhorn gave it, as if with argument 40, at 2 h. 38 m.

It will be noticed here that in the first two instances the actual argument was, in one 32 and in the next 34; and it would be imagined that the Professor would have stated the time-equivalent for 30, and not for 40, as the ending-time of the nakshatra, but he selected 40. The time-equivalent for

argument 30 is 1 h. 58 m., which differs from the *Ind. Cal.* result by only 8 m. in the first case. By using argument 40 and stating the time as 2 h. 38 m., he differed from the *Ind. Cal.* result by 32 m. Again, in the second case he chose for argument the multiple of 10 *higher* than the *Indian Calendar* actual. But in the last case, where by the *Ind. Cal.* we have the argument 45 and time-equivalent 2 h. 57 m., he chose for argument the *lower* multiple of 10, viz., 40 and not 50; and quoted the time, with argument 40, at 2 h. 38 m. I am at present unable to explain his reason for this.[1]

123. Nor am I altogether satisfied that the Professor's method is the safest. Thus, working some of these cases by Jacobi's *Epig. Ind.* General Tables, I find that in the first case where the *Ind. Cal.* result is 14 h. 14 m., Jacobi's result is 14 h. 10 m.; whereas Kielhorn stated it as 14 h. 27 m. In the same inscription where the *Ind. Cal.* (Garga) result is 2 h. 6 m., Jacobi's result is 2 h. 3 m.; whereas Kielhorn stated it as 2 h. 38 m. In the second instance where the *Ind. Cal.* result was 2 h. 14 m., Jacobi's result is 1 h. 53 m., whereas Kielhorn stated it as 2 h. 38 m. So that in these cases Jacobi's result is closer to the *Ind. Cal.* result than is Prof. Kielhorn's.

124. I believe that Kielhorn's method was based on the hope that by adopting it he would lessen the possible error arising from our multiplication of *c* by 10. Let us examine a case. I take the example given in *Ind. Cal.*, pp. 81 and 97, where $c = 439$ and the nakshatra-index resulting is 3022, showing (*Tables VIII. and X.*) that the nakshatra Āślēshā ended at 20 h. 23 m. after mean sunrise on the day in question. Now if instead of 439 as the value of *c* we had had 438 or 440, $c \times 10$ would equal 4380 or 4400, and the resulting nakshatra-index *n* would have been 3013 or 3032; the former proving Āślēshā to have ended 20 h. 59 m., the latter 19 h. 44 m. after mean sunrise. In the former case there would have been a difference of 36 m., and in the latter 39 m. between the result and our finding of 20 h. 33 m. We found, for $c = 439$, that the end of Āślēshā was, in terms of *n*, 311 from mean sunrise, and the question is what Prof. Kielhorn would have fixed as its value. He might have taken either 310, the nearest, or 320, the next highest, multiple of ten. In the former case he would have fixed the ending-time of Āślēshā as 20 h. 19 m., in the latter as 20 h. 59 m. after sunrise, and he would have differed from our *Ind. Cal.* finding by 14 m. or by 26 m. But not being certain that the *c* from which we work was not 438 or 440 instead of 439 he felt, probably, that his result, based on a difference in *n* of less than 10, was more likely to be correct than our own difference, which amounts to 10 either way. It must be noted, however, that supposing he had selected the higher multiple of 10 in the final argument, and supposing the real value of *c* to have been 440, he would have differed from the approximately true result by (20 h. 59 m. — 19 h. 44 m.) 1 h. 15 m. So that I repeat that I am not altogether satisfied that his method is the best.

Prof. Jacobi's method is, as stated above, undoubtedly more accurate than ours, and may be resorted to for testing close or doubtful cases.

125. Nakshatras, when considered with reference to their currency at mean sunrise of a civil day, are subject to nominal intercalations and suppressions in the same way as tithis and lunar months and (in the matter of suppression) Jovian samvatsaras (*above*, §§ 86–89, 95–103; *below*, §§ 131, 133). For a nakshatra may begin or end at any moment of a civil day, and it sometimes happens that the same nakshatra is current at two successive sunrises, and sometimes that a nakshatra falls altogether within the period of two successive sunrises. The rule therefore is that a nakshatra during the duration of which the sun rises twice is repeated, and that a nakshatra during which the sun does not rise at all is expunged.

Instances of this are given in the Pañchāṅg extract on p. 14 of the *Indian Calendar*. On Sunday, September 9th, A.D. 1894, the nakshatra Pūrvā Ashāḍhā ended 58 gh. 11 p. after sunrise, and at that moment Uttarā Ashāḍhā began. The hour was 5.16 a.m. on the Monday, or before sunrise. Uttarā

[1] It was not due to the fact that he selected a higher figure because equation *c* was increasing, and a lower because it was decreasing. In the first two inscription-dates under discussion he selected the higher figure, yet equation *c* was increasing in the first and decreasing in the second.

Ashāḍhā ended at 4 gh. 35 p., or at 7.50 a.m., on the Tuesday. Both sunrises of Monday and Tuesday were included in it, and therefore it was repeated. On Thursday, September 27th, the nakshatra Maghā ended 3 gh. 4 p. or 1 h. 14 m. after sunrise, and the next nakshatra, Pūrvā Phalgunī, then began. It ended 59 gh. 55 p., or 23 h. 58 m. after the same sunrise and before sunrise the next day. There was no sunrise in Pūrvā Phalgunī and, for civil-day nomenclature, it was expunged. (§ 35, *p.* 19, *and Note* 1, *Ind. Cal.*)

126. A yōga is the period of time during which the joint motion in longitude, or the sum of the motions, of the sun and moon is increased by 13° 20′, or the twenty-seventh part of the circle. We call the yōga *y*. *y* therefore equals the apparent longitude of the moon (n) + the apparent longitude of the sun (s); or $y = s + n$, and, since $n = t + s$ (*see above*), $y = t + 2s$. Thus, taking the *Ind. Cal.* (pp. 81, 97) example where at sunrise $s = 1559$, and $n = 3022$, we find $y = s + n$, or $= 4581$. Equally, t being 1463, and $2s$ (1559×2) being 3118, we find by the formula $y = t + 2s$ the same result, 4581. For beginning and ending of the current yōga, which by Table VIII. was Vyāghāta (4444 to 4815), we have respectively $4581 - 4444 = 137 =$ (Table X.) 6 h. 6 m. + 2 h. 15 m. = 8 h. 21 m. before sunrise, and $4815 - 4581 = 234 =$ 12 h. 12 m. + 2 h. 4 m. = 14 h. 16 m. after sunrise. The yōga, like the nakshatra, has, each, its special name.

Yōgas.

127. The karaṇa is half a tithi. The first half of each tithi belongs to one karaṇa, the second half to another. The names are given in cols. 4, 5 of Table VIII.; and it will be observed that, with the exception of the first half of the first tithi, the second half of the 29th and the two halves of the 30th, which have their own names, the rest consist of a repetition of seven names in order. The karaṇa is sometimes, but not often, mentioned in dates (*see* § 10, *p.* 3, *Ind. Cal.*), but it is an important element in astrological calculations. In the Pañchāṅg extract (*Ind. Cal.*, pp. 14, 15) the karaṇa current at each sunrise is stated by name, with the time of its ending in ghaṭikās and palas. Thus, the first tithi, it will be seen, ended at 43 gh. 59 p. after sunrise on Friday and the second tithi then began. It lasted till 39 gh. 47 p. on the Saturday. It therefore lasted for (60 gh. — 43 gh. 59 p.) 16 gh. 1 p. + 39 gh. 47 p., or 55 gh. 48 p. Half of this is 27 gh. 54 p., 16 gh. 1 p. of which belonged to Friday. Hence the first half of the tithi expired and the second began at 11 gh. 53 p. after sunrise on the Saturday, and this is the hour noted in the Panchāṅg. At the Friday sunrise Kiṁstughna was the current karaṇa. Bava succeeded it when half the first tithi had expired, viz., at 16 gh. 30 p. after sunrise, and Bava ended with the expiration of the tithi at 43 gh. 59 p. on the Friday. Then began Bālava, which was current at the Saturday sunrise and lasted till (as found) 11 gh. 53 p., when Kaulava began and lasted till the end of the second tithi at 39 gh. 47 p., and so on.

Karaṇas.

128. When a date is worked according to our *a, b, c* system, and the final *t*, or tithi-index is accurately found, it is easy to determine the karaṇa, whether current at any moment or current at sunrise, from the value of *t*. Take, again, the example on p. 81 of the *Indian Calendar* where the *t* was found to be 1463 at sunrise. Col. 3 of Table VIII. shows that the fifth tithi was then current, lasting from 1333 to 1667. A half-tithi is about 166½. 1333 + 166½ = 1499½. Therefore 1463 falls in the first half, and at sunrise that day Bava was the current karaṇa.

Karaṇas are not in themselves subject to repetition or expunction. (§§ 88, 89, *above.*)

129. As an example of the working of karaṇas in the case of repeated and expunged tithis we will take the cases of the repeated tithi 13th śukla and the expunged tithi 7th krishṇa (in respectively the first and second fortnights) of the lunar month contained in the Pañchāṅg extract already referred to. It will be observed that the 12th śukla tithi ended on Tuesday at 56 gh. 44 p.,[1] the karaṇa Bava having been current at sunrise and ending at 24 gh. 14 p. At that moment (*see the List in Table VIII.*) Bālava began, and it ended with the tithi at 56 gh. 44 p. Then began the karaṇa Kaulava, which was

[1] These times are measured from sunrise. They can be turned into hours and minutes by Table XXV.

current at sunrise on the Wednesday and ended at 29 gh. 3 p. that day, when Taitila began. Taitila ended with the ending of the tithi at 1 gh. 23 p. on the Thursday, and it was current at sunrise that day. The 14th tithi and the karaṇa Gara began at 1 h. 23 p. on the Thursday and lasted till half the tithi had expired, when Vaṇij began and lasted till the end of that tithi at 5 gh. 18 p. on the Friday, being current on Friday sunrise. This will show that though, as connected with the two sunrises of Wednesday and Thursday, the number of the 13th śukla tithi was repeated, neither the tithi itself nor consequently the karaṇas are repeated, but run their regular course. And the same will be seen to be the case with the "expunged" tithi, the 7th kṛishṇa.

THE SIXTY-YEAR CYCLE OF JUPITER.

General remarks.

130. (*Indian Calendar*, §§ 53 to 62.) In this reckoning each calendar year, solar or lunar, receives an appellation from a list of sixty names given in the *Indian Calendar*, Table XII., col. 1, and each such year when so named is known as a Bārhaspatya, or Jovian, saṁvatsara. The reckoning is used now more or less freely throughout India, but is particularly prevalent in Central and Southern India, especially in the western parts. The existence of it is carried back by an inscriptional instance to A.D. 602, and to a somewhat earlier period by the fact that it is taught by Varāhamihira, who died in A.D. 587. Its use seems to have been established by A.D. 550. (§ 12, *above*.)

130A. This cycle now has an astronomical basis only to a limited extent in Northern India; otherwise it simply furnishes names, each in turn, for the solar or lunar years according to the local calendar. But originally it was astronomical everywhere, and each saṁvatsara was the period occupied by the planet Jupiter in passing by his mean motion through one sign, or 30°, of the Hindū zodiac. The cycle is generally treated as beginning with the Prabhava saṁvatsara as No. 1; but, referred back on its astronomical basis to the beginning of the Kaliyuga in 3102 B.C., it began with No. 27, Vijaya; and this saṁvatsara is treated as No. 1 by the *Present Sūrya Siddhānta* and its followers. Since, however, the point of importance is the *name* of the saṁvatsara, and not its serial number, we may adopt whichever system we prefer; and I begin my Tables with Prabhava as No. 1, principally because that is the system used in the *Indian Calendar*, to which constant reference must be made by those who use my Tables.

131. The length of the saṁvatsara is roughly about four days less than that of the sidereal solar year, and it will be seen that each of the principal Hindū authorities differs slightly with regard to it. The exact figures by each authority are given below, calculated to four places of decimals. If, therefore, we imagine a saṁvatsara to begin exactly at the moment of the apparent sidereal Mēsha saṁkrānti of any year, the next saṁvatsara will begin about four days before the end of that year. And as this is the case with each successive saṁvatsara a time will come when one saṁvatsara will both begin and end within the limits of the solar year. Now the ordinary practice is to give to each solar year the name of the saṁvatsara actually current at the moment of its commencement, or in other words at the moment of Mēsha saṁkrānti, and whenever a saṁvatsara both begins and ends within the limits of a solar year we have three saṁvatsaras connected with two solar years. Calling the former A, B, C, and the latter 1, 2, A was current at the Mēsha saṁkrānti of 1, C was current at the Mēsha saṁkrānti of 2, and therefore, when naming the year 2 after the name of the saṁvatsara, B was dropped out, or, as we say, was "expunged" or "suppressed." Let it be remembered that when we speak of a saṁvatsara as expunged, this expunction merely means the omission to give to a solar or luni-solar year the name of that saṁvatsara, and does not affect the duration of the saṁvatsara itself which always runs its full course. Such an "expunction," or omission of one of the names, occurs once in every 85 or 86 years.

132. The general rule is that the name of the saṁvatsara current at Mēsha saṁkrānti of any year is attached to all the days of that year, notwithstanding that another saṁvatsara may have begun before its close. Suppose No. 8, Bhāva, to have been current at Mēsha saṁkrānti of a certain year, but to have ended a month later, when No. 9, Yuvan, began; still, all the days of that solar year will be considered to belong to the saṁvatsara named Bhāva. Occasionally, however, inscriptions may be found naming the saṁvatsara actually current on the given day, which for eleven months of such a year would be Yuvan; thus indicating the use of the astronomical instead of the conventional saṁvatsara. Epigraphists must be prepared for such a variation. A case in point will be found in Example 51 below.

133. They must also be prepared for other variations in practice. By the use of a different Siddhānta a different saṁvatsara will often be expunged. And in many tracts where lunar years were in regular calendrical use the saṁvatsara current at sunrise on the first civil day of the year, or Chaitra śukla 1, will be found to give its name to that year; in which case, since the ordinary lunar year is shorter (354 days) than the Jovian year (361 days), an expunction of a saṁvatsara can only occur in those lunar years in which there is an intercalated month. The Jyōtishatattva rule gives the saṁvatsara current at *mean* Mēsha saṁkrānti of any particular year.[1] I have not given a separate Table for it, because its results are the same in time as results found by use of the *First Ārya Siddhānta*. For similar reasons I omit notice of the Bṛihat Saṁhitā and Ratnamālā rules (*Ind. Cal.*, § 59, *p.* 35, *and note* 1, *p.* 36).

134. The question as to how far the calculated mean longitude of Jupiter according to the Hindū authorities was in accordance with the results of modern European science is one with which we have no concern.

135. In the *Indian Calendar* (*Table I., col.* 7) we have given the names of the saṁvatsaras current at apparent Mēsha saṁkrānti of each sidereal solar year from K.Y. 3401 to 4600 expired, calculated by the *Sūrya Siddhānta* without the bīja, and with the bīja from K.Y. 4601 to 5001;[2] but we have not given the exact times of the beginning and ending of each saṁvatsara—often a point of very considerable importance. In Article 59 we gave the full detailed rules for finding these beginnings, and therefore for finding the saṁvatsara current on any day of any year by (1) the *Sūrya Siddhānta*, both with and without the bīja, (2) the *First Ārya Siddhānta*, (3) the *Jyōtishatattva* rule, (4) the *Bṛihat Saṁhitā* rule; and in Article 60 we have given a comparative list of the saṁvatsaras expunged by these different systems. But these rules are rather troublesome and lengthy to work. Easier methods were propounded by Prof. Kielhorn (*Ind. Ant. XVIII., pp.* 193, 380) and Prof. Jacobi (*Epig. Ind. I., pp.* 424–28); but in my opinion the easiest is the process suggested by Mr. Shankar Balkrishna Dikshit, which, while adapted for the use of those who possess the *Indian Calendar*, is quite as reliable as any other. He had furnished Dr. Fleet with two short Tables, referred to the years of the Śaka era and worked to three places of decimals, but without any explanation of how he arrived at the figures recorded. Dr. Fleet kindly gave me a copy of these, with some valuable suggestions of his own; and after careful examination and prolonged study of the Tables, I succeeded in unravelling the whole working system. I then prepared my own Tables XXVII. to XXXI.A; calculating to nine places of decimals so as to ensure accuracy, but stating only four places for convenience. I refer my Tables to years of the Kaliyuga as being

[1] Dr. Fleet informs me that, so far as he is aware, no Hindū authority bases its calculations and rules for finding the current Jovian saṁvatsara on apparent Mēsha saṁkrānti, but all base them on mean Mēsha saṁkrānti, leaving it to anyone interested to adapt the result to the first of these times. I have prepared all my Tables (unless specially stated to the contrary) for apparent Mēsha saṁkrānti because, the time result being the same in each case, the calculator is in this way saved the trouble of changing the apparent Mēsha saṁkrānti times given in Table I. of the *Indian Calendar* into mean Mēsha saṁkrānti times.

[2] The *Sūrya Siddhānta*, before the bīja or correction was introduced into it, stated the number of revolutions of Jupiter in the mahāyuga of 4,320,000 solar years as 364,220. The author of the bīja, apparently about A.D. 1500, reduced the estimate of these revolutions of Jupiter to 364,212 in the same period; thereby slightly lengthening the duration of a saṁvatsara. (*See Table XXXVII., col.* 6.)

applicable to all eras. Mr. Dikshit's two Tables were based on the *Sūrya Siddhānta* without the bīja, but his principles apply, *mutatis mutandis*, to the other authorities, and for some of these I have worked out the figures. Every step taken, with the reason for it, is fully explained below. The first of each pair of Tables gives, calculated by Jupiter's mean motion, the number of days and decimals of a day by which the first saṁvatsara, Prabhava, of a cycle began after apparent Mēsha saṁkrānti of the solar year concerned. The second enables us to find the beginning time of each subsequent saṁvatsara of the cycle. It is a system founded on actuals as laid down by the different Siddhāntas, each for itself,—of extreme simplicity and yet yielding a final result quite as accurate as those obtained from more complicated processes.[1]

136. These pairs of Tables are to be used in the following manner (I retain as far as possible Mr. Dikshit's own words). Take as an example Tables XXVII. and XXVII.A, calculated according to the *Sūrya Siddhānta* without the bīja. The others are used in the same way, each for the authority quoted.

137. Note in Table XXVII. the expired year of the Kaliyuga next to but earlier than the expired Kaliyuga year corresponding to the given year; for which purpose the given year, in whatever reckoning it may be stated, must be converted into a year of the Kaliyuga (*Table I., or Table II. Part III.*). In the noted K.Y. year of Table XXVII. No. 1, Prabhava, of the cycle began after apparent Mēsha saṁkrānti by the number of days and decimals of a day given in col. 3. Subtract from the K.Y. figure corresponding to the *given* year the figure of the K.Y. year in which there began the Prabhava saṁvatsara which occurred last before the given year (for which the calculation is to be made), and add one to the remainder. With the resulting number as index turn to Table XXVII.A and find it in col. 1. If the number of days opposite to it in col. 3 is less than the number in Table XXVII., col. 3, against the year in which 1 Prabhava began, then the saṁvatsara in col. 2, Table XXVII.A, will begin in the given year. If not, then it began in the preceding year, and the next saṁvatsara will begin in the given year.[2] The saṁvatsara being thus determined take from Table XXVII.A, col. 3, the number of days opposite to it, and subtract them from the number of days given in Table XXVII. for the beginning of 1 Prabhava of the cycle; or, if the former be greater, subtract them from that number of days increased by 365.2588.[3] The remainder will be the number of days by which, in the given year, the saṁvatsara will begin after the time of apparent Mēsha saṁkrānti. This, converted to time by Table XXXVI., and added to the time of the apparent Mēsha saṁkrānti found from Table I. (*Ind. Cal.*), cols. 13 and 17A, or by the rules given above, fixes the month, day, and time of day when the saṁvatsara began.[4] Its end is ascertained by adding the length of one saṁvatsara, in this case 361.0267 days, to the time of its beginning. In using Table IX. of the *Indian Calendar* to ascertain the day of the month, deduct a day from the total if the day on which the Jovian saṁvatsara began was later than February 29th in a Leap-year.

Working Rule.

The same working rule applies to the other pairs of Tables, *mutatis mutandis* (*See examples* 48 *to* 59A.) The reasons for the process in each case are fully given below.

138. It will sometimes be found that a saṁvatsara current at mean Mēsha saṁkrānti was not current at apparent Mēsha saṁkrānti, and therefore that the name of a different saṁvatsara was given to the solar year concerned; but this does not affect the month, day, and time of day at which the saṁvatsara began and ended. That always remains the same.

[1] I differ from Mr. Dikshit by about 3½ minutes of time in the final result throughout, my resulting time being in each case by so much earlier than his. I have given in the text a very complete explanation of my process, and enabled its accuracy to be tested by anyone. And as proof that my figures are correct I would refer my readers to Example 50 below. In that case the full *Sūrya Siddhānta* working yields a result 23 h. 46 m. 5 s. on a certain day. The result by my Tables is 23 h. 46 m. 41 s. on the same day. The result by Mr. Dikshit's Tables is 23 h. 50 m. 11 s.

[2] In each case of course the previous saṁvatsara was *current at* apparent Mēsha saṁkrānti of the given year.

[3] Really 365.258756481, the length of the solar year.

[4] See also "Hint" No. 20, below.

139. Note that the interval of solar years between each Prabhava saṁvatsara is 60 when there is no suppression of a saṁvatsara in the cycle, 59 if there is one.

140. To find in what sign of the zodiac Jupiter stood at any time it is only necessary to calculate the ending-time of the saṁvatsara current at Mēsha saṁkrānti of the solar year. If the given day and time were earlier than that ending-time, that saṁvatsara—if later, the next following saṁvatsara—was current. The last column of Table XXXII. shows the sign in which Jupiter stood according to his mean longitude during the currency of the saṁvatsara so found.

Calculation by true longitude is dealt with separately.

Calculation by the Sūrya Siddhānta without the Bīja.

141. For all purposes of chronology the Kaliyuga era begins at mean sunrise, taken as 6 a.m., on Friday, February 18th, 3102 B.C.; and that moment is the chronological "epoch" of the reckoning. The astronomical theory takes as the starting-point of the reckoning a general conjunction of the sun, the moon and the planets at the first point of the sign Mēsha, the initial point of the Hindū ecliptic; in other words an occasion on which the sun, the moon and the planets were considered as having been all on a line drawn from the earth to the First Point of Mēsha, so that the longitude of them all was then 0°. The *Āryabhaṭīya*, or *First Ārya Siddhānta*, places this conjunction at the chronological moment specified above, namely mean sunrise, or 6.0 a.m., on Friday, February 18th, 3102 B.C.; this may be called the "sunrise epoch" of the reckoning. The *Present Sūrya Siddhānta* places the conjunction at the preceding midnight; this may be called the "midnight epoch" of the reckoning;[1] and this latter work treats the mean Mēsha saṁkrānti as occurring at that midnight, and the sixty-year cycle of Jupiter as beginning with the saṁvatsara No. 27, Vijaya, commencing at that same moment.

142. The elements of the *Sūrya Siddhānta* without the bīja are as follows:[2]—

A.	Civil days in a mahāyuga of 4,320,000 solar years .	1,577,917,828 days.
B.	Revolutions of Jupiter in that period	364,220
C.	One revolution, or A ÷ B	4332.3206523529 days.
D.	One saṁvatsara, *i.e.*, the planet's passage, by mean motion, through one sign, or 30° of arc; or C ÷ 12	361.026721029 days. (361 d. 0 h. 38 m. 29 s.)
E.	Length of sidereal solar year	365.258756481 days. (365 d. 6 h. 12 m. 37 s.)
F.	Difference between lengths of solar year and saṁvatsara; or E — D	4.232035452 days. (4 d. 5 h. 34 m. 8 s.)
G.	Śōdhya, or time-interval between true and mean Mēsha saṁkrānti (*see above*, § 39A, *etc.*)	2.170694 days.[3] (2 d. 4 h. 5 m. 48 s.)
H.	Difference between solar year-length, E, and saṁvatsara-length in one whole cycle, or F × 60 . . .	253.922127120 days.
I.	E — H, or additive difference for beginnings of successive cycles	111.336629361 days.

[1] The preceding passage has been remodelled from my original draft at Dr. Fleet's suggestion, whose article on the Kaliyuga era may be referred to. (*Journal of the Royal Asiatic Society*, 1911, pp. 479 ff.)

[2] I am indebted to Dr. Fleet for the following method of stating the elements, and for the values of A, B, C, D, in each case. I have verified the latter by comparison with the statements of other authorities.

[3] Mean Mēsha saṁkrānti is by so much later than true Mēsha saṁkrānti. (*Ind. Cal.*, § 26, p. 11.)

143. It is assumed that 27 Vijaya began at the instant of mean Mēsha saṁkrānti of K.Y. 1 current. It therefore began 2.170694 days after apparent Mēsha saṁkrānti of that solar year[1]; and therefore at that last point of time the preceding saṁvatsara 26 Nandana was current. Vijaya ended (2.1707 + 361.0267) 363.1974 days after apparent M.S., or before the end of the solar year. 26 Nandana was current at apparent M.S., and at the next apparent M.S. 28 Jaya was current. Therefore, with reference to apparent M.S. 27 Vijaya was an expunged saṁvatsara.

144. Since 27 Vijaya began 2.1707 days after apparent M.S. in K.Y. 1 current, the beginning of the 1 Prabhava of the next following cycle is found from that number of days, or G, + {E — (F × 34)}.

	Civil days.
E	365.2588
F × 34	— 143.8892
	221.3696
G	+ 2.1707
	223.5403

1 Prabhava, therefore, began by that number of days after apparent M.S. of K.Y. 33 expired, in 3069 B.C., and Table XXVII. begins from that point. The beginning of 1 Prabhava of the next cycle is found from this number of days + "I," and so in succession, deducting when necessary the figures for (E) the solar year-length. Thus:—

	Days.
For K.Y. 33	223.5403
"I"	+ 111.3366
	334.8769

By this number of days, No. 1, Prabhava, of the next cycle began after apparent Mēsha saṁkrānti of K.Y. 92.

	Days.
For K.Y. 92	334.8769
"I"	111.3366
	446.2135
"E"	— 365.2588
	80.9547

By this number of days after apparent Mēsha saṁkrānti, No. 1 Prabhava of the next cycle began in K.Y. 152, and so in succession.

145. As a matter of possible interest I have tabulated, supplementing Table I. of the *Indian Calendar*, the times of Mēsha saṁkrāntis (calculated according to the *First Ārya Siddhānta*, as the nearest reliable authority) for the period 58 B.C. to A.D. 299. This is my Table XXXVIII.A. It would be useless to tabulate it for any time earlier than that. Anyone who may wish to calculate a saṁvatsara for any earlier time is now provided with the means of doing so for himself. The number of complete cycles between K.Y. 33 and K.Y. 3117, both expired, which latter year corresponds to A.D. 16–17, is 52. Fifty-two times 111.336629361 days + 223.5403 days (the figure for Prabhava of K.Y. 33) is 6013.0450 days. Deduct a multiple (16) of the solar year-length, E, in days, *i.e.*, 365.258756481 × 16, or 5844.1401. The remainder is 168.9049, and by this number of days 1 Prabhava began after apparent Mēsha saṁkrānti of K.Y. 3117 expired, or A.D. 16. This is the figure tabulated in Table XXVII. The rest in succession.

[1] I have stated above that Table XXVII. is prepared with reference to apparent Mēsha saṁkrānti simply for convenience of calculation by readers using the *Indian Calendar*. The Hindū astronomers took no note of apparent, but only of mean, Mēsha saṁkrānti; and were not concerned with the former prior to the time when the true or apparent Mēsha saṁkrānti began to be used in and for their own period. Let it be remembered also that this cycle was not really in use at the beginning of the Kaliyuga. (*Note suggested by Dr. Fleet.*)

146. Table XXVII.A enables us to ascertain the exact beginning of each saṁvatsara of the cycle. 1 Prabhava of the cycle which began in K.Y. 33 began 223.5403 days after apparent Mēsha saṁkrānti. Therefore 2 Vibhava of the same cycle began F number of days earlier in the next solar year; 3 Śukla began 2 F number of days earlier in the next following solar year. Thus :—

In K.Y. 34, 2 Vibhava began (223.5403 — 4.2320) = 219.3083 days after apparent M.S.

In K.Y. 35, 3 Śukla began (223.5403 — 8.4641) = 215.0762 days after apparent M.S.

and so on. Against each saṁvatsara is entered in col. 3 the number of days to be deducted from the number for 1 Prabhava of the cycle given in Table XXVII. in order to find by how many days after apparent M.S. of its own solar year the saṁvatsara began. The time of apparent Mēsha saṁkrānti is obtained, for each year, from Table I., and this, added to the result already arrived at, gives the month, day, hour and minute of the beginning of the saṁvatsara.

147. One example will suffice (*see Sec.* 137), another being given in example 50 below. We desire to know (i) what saṁvatsara was current at apparent Mēsha saṁkrānti of K.Y. 4397 expired, A.D. 1296–7; (ii) what saṁvatsara began in that year; (iii) the time of the former's beginning; (iv) the time of its ending; (v) in what mean sign of the zodiac Jupiter stood during the course of the saṁvatsara —all these according to calculation by the *Sūrya Siddhānta* without the bīja.

(i, ii) (*Table XXVII.*). 1 Prabhava of the cycle began in K.Y. 4362, expired. 4397 — 4362 = 35 + 1 = 36. (*Table XXVII.A.*) 36 Śubhakṛit.

Answer.—(i) 35 Plava was current at Mēsha saṁkrānti, and (ii) 36 Śubhakṛit began during the current solar year.

(iii) The Mēsha saṁkrānti of K.Y. 4397, expired, marked the beginning of that year, and Plava being then current it *began* in K.Y. 4396 expired (A.D. 1295).

		Days.		
(*Table XXVII.*) For K.Y. 4362		315.4215		
(*Table XXVII.A.*) 35 Plava		—143.8892		
		171.5323		
	d.	*h.*	*m.*	
171.5323 = (*Table XXXVI.*)[1]	171	12	47	
Mēsha saṁk. K.Y. 4396 expired (*Table I.*)	85	1	45	
	256	14	32	

256 (*Table IX.*) = September 13th, A.D. 1295.

Answer.—Plava began 14 h. 32 m. after mean sunrise on September 13th, A.D. 1295. If necessary the corresponding solar month and day of the Kaliyuga year K.Y. 4396 expired can be found in the usual way.

[Prof. Kielhorn calculated this date by his own method, and quoted his result as 14 h. 31.5 m. after mean sunrise on the same day. This is sufficient to establish the accuracy of both. I might, instead of 47 m., have quoted the minutes as 46.5, the actuals being 46 m. 31 s., and in that case the two results would have exactly tallied.]

(iv) 256 d. 14 h. 32 m. + (§ 142, *D*) 361 d. 0 h. 38 m. = 617 d. 15 h. 10 m. 617 (*Table IX., right side*) = (A.D. 1296 being a Leap-year) September 8th, A.D. 1296.

Answer.—Plava ended September 8th, A.D. 1296, at 15 h. 10 m. after mean sunrise. Kielhorn gives it as 15 h. 9.9 m.

(v) By Table XXXII., col. 3, opposite 35 Plava, we find that Jupiter stood in the sign Dhanus.

[1] .53 = 12 h. 43 m. 12 s. .0023 = 3 m. 18.52 s Total, 12 h. 46 m. 30.52 s We call this 12 h. 47 m.

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BY THE SŪRYA SIDDHANTA WITH THE BĪJA.

149. In A.D. 1478 the author of an astronomical work or karaṇa called the *Makaranda*, composed at Benares, introduced a bīja, or correction, to the present *Sūrya Siddhānta* in regard to Jupiter's revolutions in a Mahāyuga, the number of which he made 364,212 (B) instead of 364,220 as before. No change was made in the number of civil days in a Mahāyuga, viz., 1,577,917,828 (A). Hence the length of one revolution of Jupiter by this authority, or A ÷ B, was corrected to 4332.415812768 days (C); and the length of one of Jupiter's saṁvatsaras, or C ÷ 12, was corrected to 361.034651064 days (D).

150. The correction was adopted generally, but of course in different years in different tracts, till it became prevalent throughout all India. I have therefore calculated the beginnings of Prabhava-years, in other words the beginnings of Jupiter cycles, freshly on this basis from the epoch of the Kaliyuga, and have embodied the results, beginning from K.Y. 4540 expired (A.D. 1439–40) in Table XXVIII. The process is as follows:—

	Civil days.
Sūrya Siddhānta solar year-length	365.258756481
Length of saṁvatsara	361.034651064
Difference, annual	4.224105417
Multiplied by	60
Difference in each cycle	253.446325020

151. To find the moment of beginning of any cycle, or the number of days by which 1 Prabhava began after apparent Mēsha saṁkrānti of any year, we have to add to the moment found for the beginning of the previous cycle 365.258756481 — 253.446325020 days, or 111.812431461 days. And first we have to ascertain the moment of beginning of the first whole cycle, with Prabhava as 1, after the epoch of the Kaliyuga. As before, we begin with the 27 Vijaya which, according to Hindū astronomers, began exactly at *mean* Mēsha saṁkrānti of K.Y. 1 current (0 expired, or 3102 B.C.). It began by the *Sūrya Siddhānta*, both with and without the bīja, 2.170694 days after apparent Mēsha saṁkrānti of that year, that being the time-difference, or śōdhya, between apparent and mean Mēsha saṁkrāntis. After this date the first Prabhava-year occurred after 34 saṁvatsaras had run.

	Civil days.
Solar year length	365.2588
Less (annual difference) 4.224105417 × 34	143.6196
	221.6392
+ (beginning of 27 Vijaya)	2.1707
Beginning of 1 Prabhava K.Y. 33 expired (3069 B.C.) after apparent Mēsha saṁkrānti	223.8099

From this point there were 76 cycles of 60 saṁvatsaras each till the year K.Y. 4540 (A.D. 1439–40).

	Civil days.
Beginning of 1 Prabhava K.Y. 33 (expired)	223.8099
76 cycles, or 111.812431461 × 76	8497.7448
Interval	8721.5547
Deduct a multiple of the solar year-length, or 365.258756481 × 23	8400.9514
Beginning of 1 Prabhava K.Y. 4540	320.6033

For the remaining beginnings of cycles we add for each cycle 111.812431461 days. This explains the figures in Table XXVIII. Those in Table XXVIII.A are similar to those in Table XXVII.A, but for the *Sūrya Siddhānta* with the bīja.

152. For convenience of reference I give here a list of elements of the *Sūrya Siddhānta* with the bīja, similar to those without it in § 142 :—

A.	Civil days in a Mahāyuga	1,577,917,828 days.
B.	Revolutions of Jupiter in that period	364,212
C.	One revolution, or A ÷ B	4332.415812768 days.
D.	One saṁvatsara, or C ÷ 12	361.034651064 days. (361 d. 0 h. 49 m. 54 s.)
E.	Length of solar year	365.258756481 days. (365 d. 6 h. 12 m. 37 s.)
F.	Difference between solar year, E, and saṁvatsara, D. .	4.224105417 days. (4 d. 5 h. 22 m. 43 s.)
G.	Śōdhya	2.170694 days. (2 d. 4 h. 5 m. 48 s.)
H.	Cycle difference, F — 60	253.446325020 days.
I.	Additive difference for beginnings of successive cycles .	111.812431461 days.

153. The work is precisely similar to that in the former case, but Tables XXVIII. and XXVIII.A are to be used in place of Tables XXVII. and XXVII.A.

By the First Ārya Siddhānta, or the Āryabhaṭiya.

154. The *First Ārya Siddhānta* came into use about A.D. 499, being the work of the astronomer Āryabhaṭa. It differs slightly from the *Sūrya Siddhānta* in the length of both the solar and the Jovian year. According to it the epoch of the Kaliyuga era was the moment of mean sunrise on February 18th, 3102 B.C., or 0 hour Laṅkā time—six hours later than that fixed by the author of the *Sūrya Siddhānta*. This was the moment of beginning of K.Y. 1 current. At this moment the longitude of Jupiter was held to be, like that of the mean sun, 0°, or in other words the Jovian saṁvatsara began exactly at the moment of mean Mēsha saṁkrānti of K.Y. 1 current. This saṁvatsara was Vijaya (No. 27), as before.

155. The elements of the *First Ārya Siddhānta* are as follows :—

A.	Civil days in Mahāyuga	1,577,917,500 days.
B.	Revolutions of Jupiter in that period	364,224
C.	One revolution, A ÷ B	4332.272173168 days.
D.	One saṁvatsara, C ÷ 12	361.022681097 days. (361 d. 0 h. 32 m. 40 s.)
E.	Length of solar year	365.2586805 days. (365 d. 6 h. 12 m. 30 s.)
F.	Difference between solar year, E, and saṁvatsara, D.	4.235999458 days. (4 d. 5 h. 39 m. 50 s.)
G.	Śōdhya	2.1475694 days. (2 d. 3 h. 32 m. 30 s.)
H.	F × 60 (cycle difference)	254.159967480 days.
I.	E — H, additive difference for successive cycle-beginnings	111.098713075 days.

156. Mean Mēsha saṁkrānti took place 2.1475694 days (= G) after apparent Mēsha saṁkrānti ; and therefore Vijaya began by that interval of time after the latter in K.Y. 1. 1 Prabhava of the next

cycle began 34 saṁvatsaras later, or at a time, after apparent Mēsha saṁkrānti of its own solar year, which is found, as before, from the formula G + {E — (F × 34)}.

	Civil days.
E	365.2587
F × 34	— 144.0240
	221.2347
G	+ 2.1476
	223.3823

In K.Y. 33 expired, therefore, 3069–8 B.C., 1 Prabhava began 223.3823 days after apparent Mēsha saṁkrānti. The number of complete cycles between K.Y. 33 and K.Y. 3117, both expired, which latter year corresponds to A.D. 16, is 52. Fifty-two times the value of I, or 5777.133079900 days, + 223.3823 days, is 6000.5154 days; and this, less a multiple of E, or E × 16, which = 5844.138888880 days, gives the figure 156.3765 days as the time after apparent Mēsha saṁkrānti in K.Y. 3117 (A.D. 16) when 1 Prabhava of the cycle then commencing began according to the *First Ārya Siddhānta*. Table XXIX. is calculated accordingly. Table XXIX.A corresponds with Tables XXVII.A and XXVIII.A, but is for use in calculations by the *First Ārya Siddhānta*.

157. Another method of calculating the difference between the solar year and the Jovian saṁvatsara, or the value for element F as stated in § 155, was shown me by Dr. Fleet. There were (B) 364,224 revolutions of Jupiter in a Mahāyuga of 4,320,000 years. There were therefore in that period (364,224 × 12) 4,370,688 Jovian saṁvatsaras. 4,370,688 — 4,320,000 = 50,688. Therefore one solar year = $1\frac{50,688}{4,320,000}$ saṁvatsara. This, reduced, is $1\frac{22}{1875}$. As the saṁvatsara = 361.02268 days, one solar year is equal to one saṁvatsara plus 361.02268 × $\frac{22}{1875}$ which = 4.235999458 days, and this is our figure for F. This explains part of the reasons for the full *Ārya Siddhānta* process as given in § 59, *b*, of the *Indian Calendar*.

158. As an example we will calculate by Tables XXIX. and XXIX.A the beginning and ending times of the saṁvatsara which, as we observe by Table XXIX., was expunged in K.Y. 3409 expired, A.D. 308–9, viz., No. 56 Dundubhi. It both began and ended in K.Y. 3409. We work for its beginning in that year. The cycle to which it belonged began in K.Y. 3354 (col. 1).

	Days.
1 Prabhava K.Y. 3354 (*Table XXIX., col.* 3)	235.5126
56 Dundubhi (*Table XXIX., col.* 3)	232.9800
	2.5326

2.5326 days = (*Table XXXVI.*) 2 d. 12 h. 47 m.

	d.	h.	m.
True Mēsha saṁkrānti of K.Y. 3409 expired (*Table I.*)	76	16	40
	+ 2	12	47
	79	5	27

79 = (*Table IX.*) March 19th, A.D. 308. On that day at 5 h. 27 m. after mean sunrise No. 56 Dundubhi began. It ended (79 d. 5 h. 27 m. + 361 d. 0 h. 32 m. 40 s., or the length of the saṁvatsara, =) 440 d. 6 h. 0 m. 440 = (*Table IX.*) March 15th of the following year. Dundubhi therefore ended exactly at noon on March 15th, A.D. 309.

For the moment of Dundubhi's beginning compare § 34, p. 59 of the *Indian Calendar* where the date was worked out by the full process of the *First Ārya*. It will be seen that the result obtained by the present Tables differs from this by only 36 s.[1]

[In case a discrepancy may be thought to exist between results by my present Tables and the

[1] Compare the result shown in Example 50, bottom of p. 118.

list printed in the Table on p. 36 of the *Indian Calendar*, it is sufficient to call attention to Mr. Sh. B. Dikshit's footnote, and to the fact that his calculations refer to *mean*, not to true, Mēsha saṁkrānti. I have fully explained my system.]

By the Original Sūrya Siddhānta.

159. This work was a standard authority in early days, but all that we know of its date is that it was known to Varāhamira who died in A.D. 587. Dr. Fleet tells me that he knows of no evidence to prove its existence earlier than the time of the *First Ārya Siddhānta* (about A.D. 500). It is not as yet known to how late a date, or in what tracts, it continued to be employed for the preparation of Pañchāṅgs (almanacs) and for astrological purposes; but since it is almost certain that during the whole time of its use calculation was carried on by the mean system—mean saṁkrāntis and solar months, mean lunar reckoning in months and their tithis—the Tables in this work for this authority are (differing from the rest whose use extended to, or began in, the period when "true" reckoning was adopted) framed with the *mean* Mēsha saṁkrānti of the year as basis. The śōdhya by the *Original Sūrya Siddhānta* being, as declared by Mr. Sh. B. Dikshit,[1] 2.23972̇ d., or 2 d. 5 h. 45 m. 12 s., a result obtained from the Tables showing by how many days a Jovian saṁvatsara began after mean Mēsha saṁkrānti, if *decreased* by this interval of time, will show by how many days it began after apparent Mēsha saṁkrānti; and will show whether, if apparent Mēsha saṁkrānti had by chance been used, the saṁvatsara was or was not expunged. But in either case the *time* of beginning and ending of the saṁvatsara will be unaltered.

The elements of the *Original Sūrya Siddhānta* are the following:—

A. Civil days in Mahāyuga	1,577,917,800
B. Revolutions of Jupiter in Mahāyuga	364,220
C. One revolution, A ÷ B	4332.320575476 days.
D. One saṁvatsara, C ÷ 12	361.026714623 days. (361 d. 0 h. 38 m. 28 s.)
E. Length of solar year	365.258750 days. (365 d. 6 h. 12 m. 36 s.)
F. Difference between solar year, E, and saṁvatsara, D.	4.232035377 days. (4 d. 5 h. 34 m. 8 s.)
G. Śōdhya	2.23972̇ days. (2 d. 5 h. 45 m. 12 s.)
H. F × 60 (cycle-difference)	253.922122620 days.
I. E — H, or additive difference for successive cycle-beginnings	111.336627380 days.

I have used my best endeavours to ascertain for certain Jupiter's position according to this authority at the moment of mean Mēsha saṁkrānti, K.Y. 0, that being the important point on which the calculations are based, and have arrived at the conclusion that, as in the case of the *Present Sūrya* and *First Ārya Siddhāntas* so in the *Original Sūrya Siddhānta* mean Jupiter was considered to have been, at that moment (sunrise in the case of the *First Ārya Siddhānta* or *Āryabhaṭīya*, the preceding midnight in the case of the two *Sūrya Siddhāntas*) precisely at the 0° point, as were the mean sun, mean moon and the other five planets. Dr. Fleet considers this as quite certain. The late Mr. Sh. B. Dikshit, after elaborate computation, also held it as proved. (*See Indian Antiquary*, XIX., 1890, *p.* 48; *p.* 50, *ll.* 6–13, 22–25.)

160. This being so, we have it that the Jovian saṁvatsara No. 27, Vijaya, began at the exact

[1] *Indian Antiquary*, Vol. 19, 1890, p. 49. From this source, also, confirmed by the adherence to them of other competent judges, I obtain the figures for "A," "B" and "E" in the statement of elements. The other elements are deduced from them.

moment of mean Mēsha saṁkrānti of K.Y. 1 current, the epoch of the Kaliyuga.[1] Then E — (F × 34) will give us the beginning moment of the No. 1 Prabhava of the next cycle.

	Civil days.
E	365.258750000
F × 34	— 143.889202818
	221.369547182

Hence we have it that No. 1 Prabhava began, in K.Y. 33, or 3069–68 B.C., 221.36955 days after mean Mēsha saṁkrānti, and Table XXX. starts from that point. I have made the calculations with nine places of decimals, but tabulate only with four places for convenience. The process is fully explained in the working for the *Present Sūrya Siddhānta*, §§ 141–146 above.

	Civil days.
I × 52	5789.504623760
	+ 221.369547182
	6010.874170942
E × 16	— 5844.140000000
	166.734170942

The beginning of Prabhava in K.Y. 3117 (A.D. 16–17) therefore took place 166.7342 days after *mean* Mēsha saṁkrānti. Table XXX. states this figure and continues the figures for the beginnings of all subsequent Prabhavas.

161. Table XXX.A corresponds to Tables XXVII.A, XXVIII.A, XXIXA., but is for use in calculations by the *Original Sūrya Siddhānta*.

162. Calculation by these Tables enables the *currency* at mean Mēsha saṁkrānti, according to the *Original Sūrya Siddhānta*, of the Jovian saṁvatsara to be correctly ascertained; but no Tables hitherto published enable us to fix for each solar year the time of occurrence of mean Mēsha saṁkrānti by that authority, and without such we cannot fix the times of *beginning and ending* of such a saṁvatsara. I have therefore prepared the accompanying Table, to enable this to be done, on the following principles.

The *First Ārya Siddhānta*[2] starts its calculations from mean sunrise on Friday, February 18th,

[1] In accordance with what I believe to be the usual Hindū practice, as explained in "Hints," No. 18, I assume that, the two moments exactly coinciding, Vijaya's beginning was theoretically taken as occurring immediately *after* the mathematical point of mean Mēsha saṁkrānti, so that, ending before the end of the solar year, Vijaya was expunged. It was considered to begin and end within the limits of one solar year.

[2] Dr. Fleet kindly helped me in this matter, and calculated the moment of coincidence thus:—

First Ārya Siddhānta.

Sunrise epoch of the K.Y. in elapsed days of Julian period, at mean sunrise, February 18th, 3102 B.C	588,466.00
1 year . . . . 365.25868055$\dot{5}$ × 3600	
1,314,931.24$\dot{9}$	1,314,931.25
	1,903,397.25
0 March, A.D. 499 . . .	1,903,376.00
	21.25

Original Sūrya Siddhānta.

Midnight epoch of the K.Y in elapsed days of Julian period, at previous midnight	588,465.75
1 year . . . . 365.25875 × 3600	
1,314,931.50 . .	1,314,931.50
	1,903,397.25
0 March, A.D. 499 . .	1,903,376.00
	21.25

Mean Mēsha saṁkrānti, therefore, took place by both authorities at 0.25, *i.e.*, 6 hours after mean sunrise, that is at noon, on Sunday, March 21st, A.D. 499. 1,903,397 ÷ 7 gives remainder 6 = Sunday. (*See note, p. 62 below.*)

3102 B.C.; the *Original Sūrya Siddhānta* from the previous midnight. The difference of the above times is 6 hours, and the year of the *Original Sūrya Siddhānta* is 6 seconds longer than that of the *Ārya Siddhānta*. The two therefore came together in (6 hours or 21,600 seconds divided by 6 seconds) 3600 years, and mean Mēsha saṁkrānti took place at precisely the same moment by each in A.D. 499, namely, on Sunday, March 21st, at noon. Table I. gives in cols. 13 to 17 the time of apparent Mēsha saṁkrānti for 1600 years by the *Ārya Siddhānta*. By adding to this the śōdhya interval, viz., 2 d. 3 h. 32 m. 30 s., we have the time of mean Mēsha saṁkrānti by that authority. A.D. 499–500, or K.Y. 3600 expired, being the year in which mean Mēsha saṁkrānti by the *Original Sūrya Siddhānta* was in exact accord with the *First Ārya Siddhānta*, we have only to add to, or subtract from (according as the given year is subsequent or prior to A.D. 499, K.Y. 3600 expired), the times of mean Mēsha saṁkrānti by that authority as thus obtained, the differences between the two as stated in the following Table, in order to find the exact time of mean Mēsha saṁkrānti in any year according to the *Original Sūrya Siddhānta*. Since Table I. begins with K.Y. 3402 current (A.D. 300) I have prepared Table XXXVIII.A giving the times of apparent Mēsha saṁkrāntis by the *First Ārya Siddhānta* from K.Y. 3043 expired, 59–58 B.C. It is not likely that the time for any earlier year will ever be required, but should it be so it can be obtained for any year, however remote, in the manner shown in Example 3. Adding the śōdhya and applying the difference as shown in the following Table, the desired result (mean Mēsha by the *Original Sūrya*) is obtained for any year. [Table XXXVIII.A is prepared for apparent Mēsha saṁkrānti so that it may correspond with Table I., cols. 13 to 17, and minimise the chance of confusion.]

TABLE.

Difference between the moments of mean Mēsha saṁkrānti as calculated by the *Original Sūrya* and *First Ārya Siddhāntas*, the difference in A.D. 499, K.Y. 3600 expired, being *nil*.

Having found the moment of mean M.S. by 1st Ā.S., obtain the same by the O.S.S. by adding the difference for years subsequent to, or subtracting it for years prior to A.D. 499, K.Y. 3600 expired.

Diff. in years.	Time difference.			Diff in. years.	Time difference.			Diff. in years.	Time difference.			Diff. in years.	Time difference.		
	H.	M.	S.		H.	M.	S.		H.	M.	S.		H.	M	S.
1	—	—	6	10	—	1	—	100	—	10	—	1000	1	40	—
2	—	—	12	20	—	2	—	200	—	20	—	2000	3	20	—
3	—	—	18	30	—	3	—	300	—	30	—	3000	5	—	—
4	—	—	24	40	—	4	—	400	—	40	—				
5	—	—	30	50	—	5	—	500	—	50	—				
6	—	—	36	60	—	6	—	600	1	—	—				
7	—	—	42	70	—	7	—	700	1	10	—				
8	—	—	48	80	—	8	—	800	1	20	—				
9	—	—	54	90	—	9	—	900	1	30	—				

Example.[1]—Required the time of mean Mēsha saṁkrānti by the *Original Sūrya Siddhānta* of A.D. 299, K.Y. 3400 expired, and of A.D. 300, K.Y. 3401 expired.

First K.Y. 3400 expired. Apparent M.S. (*Table XXXVIII.A*) by *First Ārya Siddhānta* = March 17th, A.D. 299, Day 76, Friday, at 8 h. 47 m. after mean sunrise. Add śōdhya 2 d. 3 h. 32 m. 30 s. Mean M.S. by *Ā.S.* = March 19th, Day 78, Sunday, at 12 h. 19½ m. For 200 years difference to A.D. 499 deduct 20 m. *Answer.*—Mean M.S. by *Original Sūrya Siddhānta* = March 19th, Sunday, Day 78, at 11 h. 59 m. 30 s. To be accurate (*see* "*Hint*" *No.* 20) we must add 30 s., making the time exactly 12 h.

And so for A.D. 300, when (*Hint* 20) no seconds have to be added to the time given in Table I. for true Mēsha saṁkrānti, which is 15 h. exact.

	d.	*w.*	*h.*	*m.*	*s.*
Apparent Mēsha saṁk. by *Ārya Siddh.* A.D. 300 (*Table I., cols.* 13, 14, 17)	16 March	0	15	0	
Add śōdhya by the *Ārya Siddh.*	2	2	3	32	30
Mean Mēsha saṁk. by *Ārya Siddh.*	18 March	2	18	32	30
Deduct for 199 years' diff., A.D. 300–499 (*Table in text*) 10 m. + 9 m. + 54 s.			—	19	54
Mean Mēsha saṁk. by *Orig. Sū. Siddh.*	18 March	2	18	12	36

(2 = Monday.) *Answer.*—Mean Mēsha saṁkrānti according to the *Original Sūrya Siddhānta* took place in A.D. 300, or K.Y. 3401 expired, on Monday, March 18th, at 18 h. 12 m. 36 s. after mean sunrise.

To find the times of beginning and ending of the saṁvatsara by the *Orig. Sūrya Siddh.*, therefore, we use, in the same manner as directed for the corresponding Tables prepared for the other Siddhāntas, Tables XXX. and XXX.A for the currency of the saṁvatsara at mean Mēsha saṁkrānti, and for expunctions of the same; and for the time of occurrence of mean Mēsha saṁkrānti we find from Table XXXVIII.A, or Table I., or by calculation as directed, the time of occurrence of apparent Mēsha saṁkrānti by the *First Ārya Siddhānta*, convert this to mean Mēsha saṁkrānti by the addition of the śōdhya, and convert the result to mean Mēsha saṁkrānti according to the *Original Sūrya Siddhānta* by the Table in the text. [Since the above was in type I have added Table XXXVIII.C. to the other Tables. This gives at once the time of mean Mēsha saṁkrānti by the *First Ārya Siddhānta* for a period of 576 years.]

BY THE BRĀHMA SIDDHĀNTA AND SIDDHĀNTA ŚIRŌMAṆI.

163. The *Brāhma Siddhānta* was composed by Brahmagupta in A.D. 628, and was much used for the ensuing four centuries. In A.D. 1042 appeared the *Rājamrigāṅka* which introduced a correction to most of the elements of the *Brāhma Siddhānta*, and shortly after that date the latter in its original form dropped out of use. In its altered condition it continued to be extensively resorted to, and it is not improbable that it was in use in, at least, the central belt of India till a comparatively late date. For all purposes connected with the position of Jupiter in relation to the sun the elements of the *Siddhānta Śirōmaṇi*, which was written by Bhāskarāchārya in A.D. 1150, are identical with those of the

[1] To give another example. In the *Indian Antiquary*, XIX. (1890), pp. 48, 49, Mr. Sh. B. Dikshit stated, after calculating in a different way, that in A.D. 505 (K.Y. 3606 or Ś. 427, both expired) mean Mēsha saṁkrānti occurred at 48 gh. 9 p. after mean sunrise on Sunday, March 20th, or, in European reckoning, at 19 h. 15 m. 36 s. after mean sunrise, according to the *Original Sūrya Siddhānta*. Working as laid down in the simple rule given in the text, I obtain—after adding to the time of true Mēsha saṁkrānti by the *Ārya Siddhānta* as given in Table I. the 30 seconds necessary for accurate calculation (*see* "*Hints,*" *No.* 20, *below*)—precisely the same result.

Brāhma Siddhānta; consequently the resulting figures and times are the same, and Tables XXXI. and XXXI.A are to be used for both these authorities. (*See the notes preceding Table XXXVII.*)

According to the *Brāhma Siddhānta* the solar year was one of 365.2584375 days, or 365 d. 6 h. 12 m. 9 s. The length of the Jupiter saṁvatsara was 361.020007456 days. The difference between the two was 4.238430044 days. In 60 saṁvatsaras this amounts to 254.305802640 days, and 365.2584375 — 254.305802640 = 110.952634860 days, which as explained above under the "general remarks," gives us the necessary element for the preparation of Table XXXI. for the beginning times of the first Prabhava of each cycle.

164. I have been unable to obtain any valuation according to Hindū authority for the śōdhya interval by this Siddhānta at K.Y. 0, on which depends the starting point for my calculations; but Dr. Schram fixes it as 2.171973, or 2 d. 4 h. 7 m. 38½ s., and this I accept. But, arguing by analogy from calculated results for the same interval according to the *Sūrya* and *Ārya Siddhāntas* made by the Hindūs and by Dr. Schram, it is possible that the Hindūs made this śōdhya from one to two-and-a-half minutes longer than does Dr. Schram. Consequently it is possible that we may approximate to Hindū calculation if we deduct (say) 2 minutes from the final result obtained by use of Tables XXXI., XXXI.A.

165. We have first to find, according to the *Brāhma Siddhānta*, the time, measured from the moment of true Mēsha saṁkrānti,[1] of the 27 Vijaya which began in K.Y. 0. In the case of the *Sūrya* and *First Ārya Siddhāntas* this was easy, because the Hindūs calculated that 27 Vijaya began at the moment of solar mean Mēsha saṁkrānti of that year, and therefore that it began by exactly the amount of the śōdhya interval later than apparent Mēsha saṁkrānti. But according to the *Brāhma Siddhānta* the place of Jupiter at the moment of solar mean Mēsha saṁkrānti in K.Y. 0 was not 0° but 359° 27′ 36″, in other words he was short of long. 0° by 32′ 24″. Since 27 Vijaya began at the moment when Jupiter reached 0°, the saṁvatsara actually current at the moment of solar mean Mēsha saṁkrānti at K.Y. 0 was 26 Nandana; and 27 Vijaya began later by the time occupied by Jupiter in travelling 32′ 24″ of arc. This, by Table XXXIV., = 6 d. 12 h., or 6.50 d.; but Dr. Schram has made a closer calculation based on the time (C, below) occupied by Jupiter in travelling 360°, and he finds that the proper figures are 6.49836 d., or 6 d. 11 h. 57 m. 38.3 s. At this distance of time, then, after the sun had reached mean long. 0°, or after the moment that marks the epoch of the Kaliyuga, Jupiter arrived there. Dr. Schram tells me that the true sun had reached long. 0° 2 d. 4 h. 7 m. 38½ s., or 2.171973 d. earlier than the mean sun. Hence 27 Vijaya began, by the *Brāhma Siddhānta* (6.49836 d. + 2.17197 d. =) 8.67033 d., or 8 d. 16 h. 5 m. 17 s. after apparent solar Mēsha saṁkrānti at K.Y. 0.

166. The following are the elements of the *Brāhma Siddhānta*, lettered in the same way as in the case of the other Siddhāntas, reduced for the Mahāyuga from the original figures which are stated for the Kalpa:—

A. Civil days in Mahāyuga	1,577,916,450.
B. Revolutions of Jupiter in Mahāyuga	364,226.455
C. One revolution, A ÷ B	4332.240089479 days. (4332 d. 5 h. 45 m. 43.7 s.)
D. One saṁvatsara, C ÷ 12	361.020007456 days. (361 d. 0 h. 28 m. 49 s.)
E. Length of solar year	365.2584375 days. (365 d. 6 h. 12 m. 9 s.)
F. Difference between solar year, E, and saṁvatsara, D,	4.238430044 days. (4 d. 5 h. 44 m. 20 s.)

[1] It is probable that calculation by mean longitudes had been abandoned from the time that the *Brāhma Siddhānta* came largely into use.

G. Śōdhya in K.Y. 0 (by Dr. Schram)	2.171973 days. (2 d. 4 h. 7 m. 38.47 s.)
H. F × 60, or cycle-difference	254.305802640 days.
I. E — H, or additive difference for beginnings of cycles .	110.952634860 days.
Jupiter's place at the epoch of the Kaliyuga era, *i.e.* at mean Mēsha saṁkrānti of K.Y. 0	359° 27′ 36″

167. We have found that 27 Vijaya began 8 d. 16 h. 5 m. 17 s., or 8.67033 d., after apparent solar Mēsha saṁkranti at K.Y. 0. To find when No. 1 Prabhava of the next cycle began we must add this amount to E — (F × 34).

E	365.258437500
F × 34	— 144.106621496
	221.151816004
	+ 8.67033
	229.822146004

Therefore, in K.Y. 33 expired (3069–8 B.C.) No. 1 Prabhava began 229.8221 days after apparent solar Mēsha saṁkrānti. This, plus 52 times the value of I and minus a multiple of E, or E × 16, gives us the number of days after apparent solar Mēsha saṁkrānti by which No. 1 Prabhava began in K.Y. 3117 expired, *i.e.*, in A.D. 16, since 52 cycles had elapsed by then.

I × 52	5769.537012720
	+ 229.822146004
	5999.359158724
	— 5844.135000000
	155.224158724

Table XXXI. states this as 155.2242, and continues the series for the beginnings of subsequent cycles; Table XXXI.A corresponds to Table XXVII.A, but is for the *Brāhma Siddhānta* and *Siddhānta Śirōmaṇi*.

167A. Calculation by Tables XXXI. and XXXI.A (when these alone are used) enables us to ascertain the currency of the saṁvatsara in relation to the solar year; but we cannot fix in European time the moment of beginning or ending of each saṁvatsara unless we know, according to the *Brāhma Siddhānta* and *Siddhānta Śirōmaṇi*, the moment of occurrence of apparent or mean Mēsha saṁkrānti of the year in question. This is not given in Table I. of the *Indian Calendar* nor in any Table as yet, to my knowledge, published, but it can be found by use of the following Table. I must first explain its principles.

The *Brāhma Siddhānta* and *Siddhānta Śirōmaṇi*, equally with the *First Ārya Siddhānta* or *Āryabhaṭīya*, recognise the sunrise epoch of the Kaliyuga, viz., mean sunrise on Friday, February 18th, 3102 B.C., or February 18th, 0 h. 0 m. 0 s., placing mean Mēsha saṁkrānti at that moment.[1] Deducting the śōdhya interval as fixed by Dr. Schram for the two former authorities, viz., 2 d. 4 h. 7 m. 38½ s., we have, for true Mēsha saṁkrānti according to them, February 15th at 19 h. 52 m. 21½ s.; and deducting the śōdhya interval as fixed in the *Indian Calendar* for the latter authority, viz., 2 d. 3 h. 32 m. 30 s., we have for true Mēsha saṁkrānti by the *First Ārya Siddhānta* February 15th at 20 h. 27 m. 30 s.

Now the solar year by the *First Ārya* is (*see Table XXXVII.*) 21 s. longer than that by the *Brāhma Siddhānta* and *Siddhānta Śirōmaṇi*, and consequently there was never a year in which the

[1] They have not a *general* conjunction at K.Y. 0; their *general* conjunction of the planetary bodies was at sunris[e] at the beginning of the Kalpa, and they begin their calculations from that moment. [*Note given by Dr. Fleet.*]

First Ārya agreed with the two latter authorities as to the moments of either true or mean Mēsha saṁkrānti. On the contrary they diverged every year by 21 s., and at K.Y. 5000 expired, in A.D. 1899, the difference amounted to 1 d. 5 h. 10 m. Hence the Table.

TABLE.

Difference between the moments of mean Mēsha saṁkrānti as calculated by (1) *The First Ārya Siddhānta* (2) *The Brāhma Siddhānta* and *Siddhānta Śirōmani,* all having been together at K.Y. 0. in 3102 B.C.

Having found from Table I, &c, the moment of mean Mēsha saṁkrānti by the First Ārya Siddhānta, deduct the time-difference given in the Table in order to obtain the same by the Brāhma Siddhānta and Siddhānta Śirōmaṇi.

Diff. in years.	Time difference.			Diff. in years.	Time difference.			Diff. in years.	Time difference.			Diff. in years.	Time difference.		
1	2			1	2			1	2			1	2		
	H.	M.	S.		H.	M.	S.		H.	M.	S.		H.	M.	S.
1	—	—	21	10	—	3	30	100	—	35	—	1000	5	50	—
2	—	—	42	20	—	7	—	200	1	10	—	2000	11	40	—
3	—	1	3	30	—	10	30	300	1	45	—	3000	17	30	—
4	—	1	24	40	—	14	—	400	2	20	—	4000	23	20	—
5	—	1	45	50	—	17	30	500	2	55	—	5000	29	10	—
6	—	2	6	60	—	21	—	600	3	30	—				
7	—	2	27	70	—	24	30	700	4	5	—				
8	—	2	48	80	—	28	—	800	4	40	—				
9	—	3	9	90	—	31	30	900	5	15	—				

Rule.—Take the moment of true Mēsha saṁkrānti by the *Ārya Siddhānta* from Table I. of the *Indian Calendar;* add śōdhya, or 2 d. 3 h. 32 m. 30 s. This gives the moment of mean Mēsha saṁkrānti by that authority. Deduct from this last, for every year of the Kaliyuga expired at the given date, the amount obtained from the above Table. This gives the moment of mean Mēsha saṁkrānti by the *Brāhma Siddhānta* and *Siddhānta Śirōmaṇi.* From this deduct the śōdhya by those authorities, or, as fixed by Dr. Schram, 2 d. 4 h. 7 m. 38½ s. The result is the moment of true Mēsha saṁkrānti by these two authorities.

With this knowledge, used as before, the moments of beginning and ending of the Jovian saṁvatsara according to those authorities is found by using Tables XXXI. and XXXI.A.

Example.—We desire to fix the beginning and ending times of the Jovian saṁvatsara which was current at true Mēsha saṁkrānti of K.Y. 5001 expired, or A.D. 1900–1901, by the *Brāhma Siddhānta* and *Siddhānta Śirōmaṇi.*

The saṁvatsara began in K.Y. 5000 expired. First find the moment of true Mēsha saṁkrānti in that year by those authorities.

					h.	m.	s.
True Mēsha S. by *Ārya Siddh.* (*Table I.*)	A.D. 1899	12 April (102)	4 Wed.		6	7	0
Add śōdhya by *Ārya Siddh.*		2	2	2	3	32	30
Mean Mēsha S. by *Ārya Siddh.*		14 April (104)	6 Fri.		9	39	30
For 5000 years deduct (*Table in text*)		− 1	− 1	− 1	− 5	− 10	− 0
Mean Mēsha S. by *B.S.* and *S. Śirō.*[1]		13 April (103)	5 Thur.		4	29	30
Deduct *B.S.* and *S. Śirō.* śōdhya		− 2	− 2	− 2	− 4	− 7	− 38½
True Mēsha S. by *B.S.* and *S. Śirō.*.		11 April (101)	3 Tues.		0	21	51½

True Mēsha saṁkrānti, then, by the *Brāhma Siddhānta* and *Siddhānta Śirōmaṇi* occurred on Tuesday, April 11th, A.D. 1899, at 0 h. 22 m. after mean sunrise.

Using Tables XXXI. and XXXI.A as directed (§ 137) we have 5001 (the given year) — 4955 (the year in which the cycle began) = 46 + 1 = 47 Pramādin. Pramādin began in K.Y. 5001; and 46 Paridhāvin began in K.Y. 5000, and was the required saṁvatsara current at Mēsha saṁkrānti of K.Y. 5001. We have to find the time of beginning and ending of this Paridhāvin.

		d.	h.	m.
(*Table XXXI.*) Prabhava K.Y. 4955		307.4299		
(*Table XXXI.A*) 46 Paridhāvin		— 190.7294		
		116.7005		
This = (*Table XXXVI.*)		116	16	49
True Mēsha (as found)	+	101	0	22
Paridhāvin began		217	17	11
B.S. and *S. Śirō.* year-length	+	361	0	29
Paridhāvin ended		578	17	40

217 and 578 are respectively, by Table IX., August 5th and August 1st. Therefore we have found that 46 Paridhāvin, according to the *Brāhma Siddhānta* and *Siddhānta Śirōmani*, began on August 5th, A.D. 1899, at 17 h. 11 m., and ended on August 1st, A.D. 1900, at 17 h. 40 m., after mean sunrise at Laṅkā.

By the Second Ārya Siddhānta.

167B. Dr. Fleet tells me that the late Mahamahopadhyaya Sudhakara Dvivedi, of Benares, was engaged in editing this work, but it is not known here how far he has gone with it, and whether any instalment of it has yet been published. Dr. Fleet adds that, as far as can be ascertained, no other text of it has been published, and no translation, and there seems to be not even a manuscript of it anywhere in Europe. Bentley's *Hindu Astronomy* (1825), p. 139, gives the following details of such

[1] Dr. Fleet has tested this result for mean Mēsha saṁkrānti in K.Y. 5000 expired in another way, namely, by using the Julian period as tabulated by Dr. Schram in his *Kalendariographische und Chronologische Tafeln* (1908). According to this the sunrise epoch of the Kaliyuga was the day 588,466 elapsed. The length of the solar year according to the *Brāhma Siddhān'a* and *Siddhānta Śirōmaṇi* is 365.2584375 days. 5000 of these years = 1,826,292.1875 days To this add the epoch, *i.e.*, 588,466 days elapsed. Total of elapsed days, 2,414,758.1875. The Julian day corresponding to 0 April, 1899, is 2,414,745 days elapsed. Deduct this from the total. Remainder, 13.1875 days. 0.1875 = 4 h. 30 m. 2,414,758 ÷ 7 gives remainder 3 = Thursday.* If we add to my result the 30 seconds necessary for very accurate calculation of the time of true Mēsha saṁkrānti according to the *Ārya Siddhānta* (*see* " *Hints* " *No.* 20, *below*), which saṁkrānti occurred actually at 6 h. 7 m. 30 s., and not, as tabulated in Table I., at 6 h. 7 m. exact, then my result is precisely the same as his, *i.e.*, April 13th at 4 h. 30 m.

* The *Indian Calendar* method of reckoning makes Thursday the day No. 5, 1 being Sunday. The Julian period begins with 1 as Monday. Hence when calculated for current days Thursday would be 4, but for *elapsed* days, as here used, the first is Tuesday; and so Thursday has the numeral 3. This last is the system adopted in Dr. Schram's *Kalend. und Chron. Tafeln* (1908), p. 79, and used here by Dr. Fleet.

In calculating by days of the Kaliyuga, which is often done, note that, since the Kaliyuga begins on a Friday, when current days are used the proper numerals are 1 Friday, 2 Saturday, and when elapsed days are used the proper numerals are 1 Saturday, 2 Sunday, and so on.

I am indebted for this note to Dr. Fleet.

of its contents as are concerned with our present purposes. The *Second Ārya Siddhānta* uses the sunrise beginning of the day for astronomical as well as for civil purposes. It states its elements as for the Kalpa of 1000 mahāyugas, but it applies them from the expiry of 3,024,000 years after the beginning of the Kalpa, and so places at that point the commencement of the motions of all the planets, &c., starting from a general conjunction at the first point of Mēsha; that is, it allows 3,024,000 years (just as the *Present Sūrya Siddhānta* allows 17,064,000 years) for the process of creation.

Reduced to the mahāyuga, its figures give 1,577,917,542 civil days and 364,219.682 revolutions of Jupiter in 4,320,000 years. And Dr. Fleet has calculated that it thus places Jupiter at the sunrise epoch of the Kaliyuga in 357° 7′ 12″, precisely as stated by Whitney in *Sūrya Siddhānta* (translation), p. 281.

167C. This result differs rather appreciably from the positions assigned to Jupiter—either 0 Mēsha, or much nearer thereto—by the other authorities. And Dr. Fleet adds that the elements of the *Second Ārya Siddhānta* are stated in the kaṭapayādi system of expressing numbers—a system which might perhaps lead to the introduction of mistakes.[1] In these circumstances I think it would be rather dangerous to tabulate for the saṁvatsaras of Jupiter according to this work until we have a critical edition available of, at any rate, that part of it which contains the elements. Moreover, if Mr. Sh. B. Dikshit was correct in his belief, this work "does not seem to have been anywhere in use for a long time." (*Ind. Cal., p.* 8.)

There will be no harm, however, in stating the various elements, so far as we can gather them at present, in a List similar to that given for the other authorities. If hereafter the figures are found to be correct, the proper tabulation can be made from them in a day's work. If not, the figures can of course be corrected. At present they stand as follows:—

A. Civil days in a Mahāyuga	1,577,917,542 days.
B. Revolutions of Jupiter in that period	364,219.682
C. One revolution, A ÷ B	4332.323649659 days.
D. One saṁvatsara, C ÷ 12	361.026970805 days. (361 d. 0 h. 38 m. 50 s.)
E. Length of solar year	365.258690278 days. (365 d. 6 h. 12 m. 30.84 s.)
E. Burgess, "*Sūrya Siddh.*," p. 24. J. Burgess, *J. R. A. S.*, 1893, p. 722.	
F. Difference between solar year, E, and saṁvatsara, D	4.231719473 days. (4 d. 5 h. 33 m. 50 s.)
G. Śōdhya in K.Y. 0, as fixed by Dr. Schram . . .	2.171972 days. (2 d. 4 h. 7 m. 38 s.)
H. F × 60 (cycle difference)	253.903168380 days.
I. E — H, additive difference for successive cycle-beginnings	111.355521898 days.
Jupiter's place at K.Y. 0, mean Mēsha saṁkrānti . .	357° 7′ 12″

This position of Jupiter at the epoch of the Kaliyuga would cause a wide difference between this and the other authorities in the matter of the currency in solar years of the saṁvatsaras of Jupiter and of the expunction of the latter from time to time.[2]

[1] See his notes on this system in *Jour. R. As. Soc.*, 1911, p. 788; and 1912.

[2] Since the above was in the Press I have received a communication from Dr. Fleet, informing me that he has now received a copy of M. S. Dvivedi's edition of the *Second Ārya Siddhānta*; and that on examination of the text he finds that the elements of this Siddhānta are exactly as stated in § 167B. The elements, therefore, as given in § 167C are correct. But since the position of Jupiter according to that authority at mean Mēsha saṁkrānti of K.Y. 1 current differs widely from that stated by the other Siddhāntas, the tabulation for the Jovian saṁvatsaras by it requires special study, and it is too late for me to present the Tables in the present volume. I hope to do so elsewhere and with no long delay.

CALCULATION WITH REFERENCE TO MEAN MĒSHA SAṀKRĀNTI.

168. It is not necessary to frame separate tables for work in order to test a case of a Hindū calculator having referred the beginning-time of a Jovian cyclic year to the mean, instead of to the true or apparent Mēsha saṁkrānti; for the day, hour, and minute when that saṁvatsara began will always remain the same. The only point necessary to be remembered is that, mean Mēsha saṁkrānti taking place later than the true Mēsha saṁkrānti by the amount of the śōdhya interval (quoted above as "G" for each separate authority), whenever a Jovian saṁvatsara is found on calculation by the Tables to have begun in less than this quoted śōdhya interval after apparent Mēsha saṁkrānti, that saṁvatsara was *not* current at the moment of *apparent* Mēsha saṁkranti, but *was* current at the moment of *mean* Mēsha saṁkrānti. Such a saṁvatsara must, therefore, with reference to apparent Mēsha saṁkrānti, be an expunged saṁvatsara, since it began after that moment and must have ended before the moment of the next apparent Mēsha saṁkrānti; and with reference to mean Mēsha saṁkrānti the preceding saṁvatsara must have been expunged.

169. Supposing No. 2, Vibhava, to be a saṁvatsara quoted in an inscription as giving its name to the current year, and therefore current at Mēsha saṁkrānti in that year, and supposing we find by our Tables that it began 2 d. 3 h. after apparent Mēsha saṁkrānti; we should know at once that, whether the *Ārya* or *Sūrya Siddhānta* had been used, the framer of the record had reckoned by mean, and not by apparent, Mēsha saṁkrānti; because, if the latter had been the basis of reckoning, the saṁvatsara current at that apparent Mēsha saṁkrānti and therefore giving its name to the year would not have been 2 Vibhava but 1 Prabhava, and 2 Vibhava would have been expunged. It began, according to either Siddhānta, within such a short time after apparent Mēsha saṁkrānti that its ending, 361 days and a fraction later, must have occurred prior to apparent Mēsha saṁkrānti of the following year, and therefore it was not current at the astronomical beginning of either of the solar years concerned.

Calculations in India previous to about A.D. 1000 may always have been made with mean Mēsha saṁkrānti as the basis for ascertaining the coincidence of Jovian saṁvatsaras, and if it is desired to work our Tables on that basis it can be done in the following manner. Take the example in § 147 above (iii). Table XXVII. shows that in K.Y. 4362 No. 1 Prabhava began 315.4215 days after apparent Mēsha saṁkrānti. The *Sūrya Siddhānta* śōdhya being, as stated, taken as 2.1707 days we know that Prabhava began (315.4215 — 2.1707) 313.2508 days after *mean* Mēsha saṁkrānti. By Table XXVII.A we find that No. 35 Plava of that cycle began 143.8892 days less than 313.2508, *i.e.*, 169.3616 days after mean Mēsha saṁkrānti, or 169 d. 8 h. 41 m. after it. Now from Table I. we have it that in the corresponding solar year apparent Mēsha saṁkrānti occurred on the 85th day at 1 h. 45 m. Therefore, mean Mēsha saṁkrānti occurred 2 d. 4 h. 6 m. (the śōdhya interval) later, *i.e.*, on the 87th day at 5 h. 51 m. 87 d. 5 h. 51 m. + 169 d. 8 h. 41 m. = 256 d. 14 h. 32 m. 256 = Table IX., September 13th, A.D. 1295. And Plava began on that day at 14 h. 32 m. both when the calculation is made from apparent and from mean Mēsha saṁkrānti (*see* § 147). That is to say, the *time-result* is the same in both cases. The only difference lies in the fact that Plava began 169 odd days after mean, but 171 odd days after true Mēsha saṁkrānti. And nothing is ever affected by calculating preferentially from one or the other basis except the question of the currency at mean or true Mēsha saṁkrānti, as already stated.

DIFFERENCE IN MODE OF RECKONING IN NORTHERN AND SOUTHERN INDIA SINCE ABOUT A.D. 908.

170. The astronomical basis, explained above, of calculating the saṁvatsaras and naming after them the solar years still prevails generally in Northern India. In Southern India it was in use down

to at least about A.D. 900. A grant of the Rāshṭrakūṭa king Govinda III. from the Kanarese country, issued in a year corresponding to A.D. 804,[1] helps to prove this so far as concerns that time and place. But from the beginning of that cycle which by the *Sūrya Siddhānta* began with 1 Prabhava in A.D. 906 a change took place. The northerns continued, as before, calculating for the Jovian saṁvatsara current at the astronomical beginning of the solar year; but the southerns neglected all expunctions of saṁvatsaras after that time, ran on the complete cycle of sixty saṁvatsaras without expunctions, and generally, in tracts where lunar reckoning was employed, connected the saṁvatsara with the beginning of the lunar year. So that in every period of sixty years during which an expunction of a saṁvatsara of Jupiter took place in the north there was a difference of one saṁvatsara between the nomenclature of the year in the north and in the south; and by A.D. 1900 the saṁvatsara current in the north was No. 46 against No. 34 in the south. All this being clearly shown, for the *Sūrya Siddhānta*, in Table I. of the *Indian Calendar*, no further explanation is here necessary to be given.

171. The year K.Y. 4264 may be quoted as an example. According to northern reckoning the saṁvatsara No. 20, Vyaya, was current at Mēsha saṁkrānti of that year, *i.e.*, on March 24th, A.D. 1163. It was also current in January of that year. But in an inscription from Anumakoṇḍa of the Kākatīya king Rudradēva, of date corresponding to January 19th of that year, "16, Chitrabhānu" is quoted as the saṁvatsara of the lunar year; this is in southern reckoning (*see Kielhorn's List, Epig. Ind. VII., App.* 101, *No.* 584).

172. No calculation for the beginning or ending of the Jovian saṁvatsaras is necessary for this southern reckoning. At the beginning of each solar or luni-solar year, according to local practice, the number and name of the saṁvatsara changes serially, as if automatically, because there is never any expunction.

173. The entries in col. 6, Table I., of the *Indian Calendar* show the southern saṁvatsara connected with each of the luni-solar years. If it is desired to test the accuracy of such an entry, or to test a case where, previous to A.D. 908, a saṁvatsara given in a date is found not to correspond with the Tables, this can be done for luni-solar years by the following rule:—Add 11 to the *current* Śaka year, and divide by 60; the remainder is the corresponding cyclic saṁvatsara required.

E.g.—For the luni-solar year beginning March 14th, A.D. 910. The *current* Śaka year is 833. This $+ 11 = 844 \div 60 = 14$ with remainder 4. No. 4 Pramōda was the saṁvatsara coupled with that year in the south of India. (In this method of calculation remainder 0 gives No. 60, Kshaya, as the required saṁvatsara.)

THE TWELVE-YEAR CYCLE OF JUPITER.

174. In this system, believed to be the older of the two, the Jovian saṁvatsaras are named in succession, not according to the names of the sixty-year cycle but according to a cycle of twelve years, five of these cycles going to one sixty-year cycle in regular order. The saṁvatsaras of the twelve-year cycle are quoted either after the name of the sign (Mēsha, Vṛishabha, &c.) in which Jupiter stood, or after the names of the twelve lunar months, beginning with Āśvina (Āśvina, Kārttika, &c.). In the latter case, that of the twelve-year cycle lunar-month names, the names were sometimes distinguished by the prefix *mahā*, "great," *e.g.*, "Mahā-Chaitra," "Mahā-Vaiśākha," &c.[2]

175. These names are applied to the saṁvatsaras according to the nakshatra in which Jupiter stands on entering a sign of the zodiac. The name "(Mahā)-Āśvina" is applied to the saṁvatsara at

[1] *Ind. Ant.*, XI., 126; XXIII., 122, No. 55. The saṁvatsara quoted is in northern (astronomical) reckoning.

[2] This prefix figures in records of the Gupta series, but not in the Kadamba records (*Ind. Ant. VI.*, 25; *VII.*, 36) from Southern-India.

the beginning of which Jupiter enters the sign Mēsha because at that moment he also enters the nakshatra Aśvinī, and so on. (For the correspondence of nakshatras and signs see Table XXII.) We have to learn how these twelve-year cycle names conform to those of the sixty-year cycle, and also to know how to find the position of Jupiter amongst the nakshatras and signs. His position is calculated sometimes by his mean motion, sometimes by his apparent motion. The habit of the people who used this system —notably the people of Malabar and Tinnevelly—was to specify the sign in which Jupiter stood at a particular time. Suppose an inscription to state that Jupiter was in Mēsha at the time recorded. Since there are five cycles of twelve saṁvatsaras in one cycle of sixty saṁvatsaras, the fact that Jupiter was in Mēsha means that he was either in (*see Table XXXII.*) 3 Śukla, or 15 Vṛisha, or 27 Vijaya, or 49 Viśvāvasu, or 51 Piṅgala.

176. The easiest way to find which of the five possible sixty-year cycle saṁvatsaras corresponds to a given twelve-sign cycle saṁvatsara is to refer to Table I. If, for instance, an inscription gives the date as in the Kollam year 427 with Jupiter in Mēsha,[1] we refer to Table I. and find that Kollam 427–428 corresponds to the northern sixty-year cycle No. 51 Piṅgala; and reference to Table XXXII. shows that Piṅgala was a year in which, by his mean longitude, Jupiter stood in Mēsha.

Another way is to subtract from the number of the given year, converted to A.D. reckoning or to that of the Kaliyuga, the number of the year, by either of the latter, in which the first of the sixty-year cycle, Prabhava, began, as given in Tables XXVII., XXVIII., XXIX., XXX. or XXXI, according to the different authorities. The given year was Kollam 427. As this begins in the month Siṁha or Kanyā the Mēsha with which we are concerned is that of K.Y. 4354 expired, or A.D. 1253. No. 1 Prabhava of the sixty-year cycle began, by all the authorities noted in my Tables, in K.Y. 4303, or A.D. 1202. 4354 — 4303, or 1253 — 1202 = 51. No. 51 is Piṅgala, and by col. 3, Table XXXII., Jupiter was, during Piṅgala, in Mēsha.

177. Table XXXII. shows the correspondence of the sixty-year cycle names with the position of Jupiter, calculated by his mean motion, in the twelve signs. The Table is applicable to both Northern and Southern India down to closely about A.D. 909, and after that date to Northern India only. The saṁvatsaras both of the twelve-year sign system (*cols.* 2, 3, *Table XXXII.*) and of the sixty-saṁvatsara cycle are similar in length and begin at the same moment.

JUPITER'S MEAN LONGITUDE.

178. For special purposes we often want to know more than the correspondence of these names and signs. We may want to know Jupiter's longitudinal position amongst the signs on a particular day or hour (A) with reference to his mean, or (B) to his apparent longitude; or (C) the same with reference to the nakshatras. These are dealt with in the following sections.

179. In the "Additions and Corrections" to the *Indian Calendar*, pp. 155–161, we published a set of Tables with instructions for use, showing how to find both the mean and true longitudes, in other words the mean place and the true place, of Jupiter for any year, day and time, in ghaṭikās and palas. I now republish these in somewhat different form.

In the first place I have altered Table W., "For finding the mean place of Jupiter," by giving the constant at the heading not as from Śaka 1 current, but as from the epoch of the Kaliyuga. This enables us to obtain the mean place of Jupiter for the beginning of any year from 3102 B.C., instead of being able to begin only from Śaka 1 current or A.D. 78. It also simplifies work by eliminating the necessity for using any set of figures as constants for some of the Siddhāntas. That this course yields precisely the same results as does Table W is easily proved. I work by my new Table for the beginning

[1] As in Kielhorn's No. 2 in *Indian Antiquary*, Vol. XXV. (1896), p. 54.

of the year Śaka 1 current. That year corresponds to K.Y. 3180 current. The interval between it and K.Y. 1 current is 3179 years. By my new Table XXXIII. we have—

	Sūrya Siddh.				1st *Ārya Siddh.*				*Sūrya Siddh. with bīja.*			
	s.	°	′	″	s.	°	′	″	s.	°	′	″
3000 years . . .	11	5	0	0	11	6	0	0	11	3	0	0
100 " . . .	5	5	10	0	5	5	12	0	5	5	6	0
70 " . . .	10	24[1]	37	0	10	24	38	24	10	24	34	12
9 " . . .	9	3	9	54	9	3	10	5	9	3	9	32
	0	7	56	54	0	9	0	29	0	5	49	44[2]

And these results are exactly the same as those at the head of Table W, being there given as constants from which to work when using the Śaka era. Additional figures are given in Table XXXIII. for an interval of 4000 years and 5000 years.

180. Table Y in the *Indian Calendar* gives the mean motion of Jupiter and the sun, the latter being required for finding his true motion. This Table is now repeated as Table XXXIV. It stands for all the Siddhāntas because the difference between them, being about $\frac{1}{100}$th of a second per day, only amounts to about 2.4″ in the Julian year. (*See Table XXXVII., col.* 10.) But when we come to greater periods the difference in the length of the year by the different Hindū authorities must be taken into account, since the divergence between them begins from the epoch of the Kaliyuga and our calculations cover a period of 5000 years. Hence the divergence observable under the different headings of Table XXXIII.

180A. At the foot of Table Y of the *Indian Calendar* we gave directions for the computation of Jupiter's mean motion for portions of a day calculating by ghaṭikās and palas; but as many workers may prefer to proceed by hours, minutes and seconds, I have added a supplemental Table enabling this to be done.

181. The figures in the Tables are derived from calculations made as follows:—

According to the *Present Sūrya Siddhānta*, both with and without the bīja, the *Original Sūrya Siddhānta* and the *First Ārya Siddhānta* (of Āryabhaṭa) the planet Jupiter was, at the epoch of the Kaliyuga era in exact coincidence with the mean sun, both being then precisely on the first point of sidereal Mēsha, or the point in the heavens whence all longitudes are measured; in other words Jupiter's longitude, like the sun's, was then 0°. This moment, according to both the *Ārya Siddhāntas*, the *Brāhma Siddhānta* and the *Siddhānta Śirōmaṇi*, was mean sunrise, or 6 a.m., on February 18th, 3102 B.C.; but according to both the *Sūrya Siddhāntas* was at midnight between February 17th and 18th, or six hours earlier. Jupiter's mean daily and annual motion are obtained, according to the different authorities, each from its assertion as to the number of civil days in a mahāyuga (A) and the number of revolutions of Jupiter in that period (B), as already explained. (A ÷ B) ÷ 12 gives the length of one Jovian saṁvatsara; and one sign, 30°, divided by this length gives the mean daily motion. This mean daily motion multiplied by the solar year-length gives the mean annual motion. This last forms the basis of Table XXXIII., decimals of a second being omitted for convenience.

Having been at 0°, according to the *Sūrya Siddhānta*, at the moment of mean Mēsha saṁkrānti at K.Y. 0, Jupiter's mean longitude one whole day later was 4′ 59″, two days later 9′ 58″, one year later 1 s. 0° 21′ 6″, two years later 2 s. 0° 42′ 12″. And so for all. But in the case of the *Brāhma Siddhānta* and *Siddhānta Śirōmaṇi* the constant given in the heading, viz., 32′ 24″, must be deducted from the

[1] "14" in Table W is a misprint.
[2] "4" in Table W is also, I regret to say, a misprint.

result. Table XXXIII. thus gives the mean longitude at mean Mēsha saṁkrānti in any year later than K.Y. 0; and Table XXXIV. gives us the increase in his mean longitude for any number of days, hours and minutes elapsed to the given moment from mean Mēsha saṁkrānti of the year concerned.

182. To find the mean longitude of Jupiter, therefore, by the Tables on any day we first find the time of the true Mēsha saṁkrānti of the year in question from Table I., or as shewn below in Examples 1 and 3; add to it the śōdhya interval according to the authority we are using (*see foot of Table XXXIV.*), and thereby find the moment of mean Mēsha saṁkrānti. Calculating the number of complete years from mean Mēsha saṁkrānti of K.Y. 1 current to the mean Mēsha saṁkrānti of the given year, we find Jupiter's mean longitude at that last moment by Table XXXIII. The corresponding increase in mean longitude during the interval between mean Mēsha saṁkrānti in the given year and the given moment is obtained from Table XXXIV. and is to be added to the mean longitude at mean Mēsha saṁkrānti. We then have Jupiter's mean longitude at the given moment as required.

The sun's mean longitude at the given moment is calculated by Table XXXIV. alone, from the interval between mean Mēsha saṁkrānti of the given year and the given moment; since his mean longitude at mean Mēsha saṁkrānti of every year is 0°.

183. We cannot find Jupiter's true or apparent longitude without first determining the mean longitude both of the planet and of the sun. As we must therefore always begin by these operations it will be well to illustrate them by an example.

In E. Burgess's "Sūrya Siddhānta" will be found, on p. 34, a Table, giving amongst other information the mean place of Jupiter according to that authority, both with and without the bīja, at midnight between December 31st, A.D. 1859, and January 1st, A.D. 1860. I proceed to calculate the same by the present Tables, following the *Sūrya Siddhānta*.

The given moment fell in K.Y. 4961 current (*Table I.*). The number of whole years from mean Mēsha saṁkrānti K.Y. 0 to mean Mēsha saṁkrānti K.Y. 4961 is 4960. Apparent Mēsha saṁkrānti in K.Y. 4961 took place (*Table I.*) on April 12th (day 102), A.D. 1859, at 0 h. 16 m. after mean sunrise. Adding the śōdhya interval we find that mean Mēsha saṁkrānti took place 2 d. 4 h. 6 m. later, namely, on April 14th (day 104) at 4 h. 22 m. The interval from April 14th (104), 4 h. 22 m., to December 31st (365) 18 h., or midnight, is 261 d. 13 h. 38 m. We therefore take down the figures from Tables XXXIII and XXXIV. for 4960 y. 261 d. 13 h. 38 m., and add them together. This is the time elapsed from mean Mēsha saṁkrānti K.Y. 1 current, or the epoch of the Kaliyuga, to the given moment.

	Sūrya Siddh.				*Sūrya Siddh. with bīja.*			
	s.	°	′	″	s.	°	′	″
4000 years	2	26	40	0	2	24	0	0
900 „	10	16	30	0	10	15	54	0
60 „	0	21	6	0	0	21	3	36
200 days	0	16	37	9	0	16	37	9
60 „	0	4	59	7	0	4	59	7
1 day	0	0	4	59	0	0	4	59
10 hours	0	0	2	5	0	0	2	5
3 „	0	0	0	37	0	0	0	37
38 minutes	0	0	0	8	0	0	0	8
	2[1]	26	0	5	2	22	41	41

[1] Remember that there are 30° to 1 sign, and only 12 signs.

According to the calculation made by the authors of Burgess's "Sūrya Siddhānta" the mean places of Jupiter at the given moment by that authority with and without the bīja were found to be 2 s. 26° 0′ 7″ and 2 s. 22° 41′ 41″ respectively. My result is precisely the same in one case, and only 2″ different in the other. Further proof of the accuracy of my Tables will be found in Example 61 below.

Jupiter's true longitude.

184. I give below (*para.* 184A) an exact reproduction in my own words of the process laid down by Mr. Sh. B. Dikshit for finding the true or apparent longitude of Jupiter on any day. It will be found in § 160 (*c*), pp. 155–157 of the *Indian Calendar*, "Additions and Corrections." Mr. Dikshit was a most painstaking, careful and accurate worker, well versed in the Hindū astronomy and in European mathematics, and it is to be assumed that his process represents faithfully the method which would have been adopted, probably which *was* adopted, by Hindū calculators in both ancient and recent times; at any rate until the period when they began to depend on European almanacs and astronomical methods. If such be the case, results obtained by the use of his process will more accurately tally with the figures and fixtures of a date as calculated and determined by a Hindū Pañchāṅg than will any result obtained by a process used by a trained European astronomer. And it is for that reason that I have considered it advisable to reproduce in its integrity Mr. Dikshit's method of calculation.

But I am bound to warn my readers that Mr. Dikshit's method is open to criticism in two respects. Mr. A. C. D. Crommelin, of the Greenwich Observatory, has most kindly subjected the process to a close examination, and he raises the following objections to it. The first operation, after ascertaining the mean longitude of Jupiter as well as that of the sun at the given moment, is to deduct the latter from the former, thus obtaining the angular distance of mean Jupiter from mean sun; calling the result "V," or "the first commutation." The next process is to apply half the parallax of Jupiter to Jupiter's mean longitude, and then to subtract from the sum the longitude of Jupiter's aphelion, in order to obtain the anomaly which I call "W." Now Mr. Crommelin points out that it is wrong at this stage to apply any parallax at all; for, so far as the calculation has proceeded, we are not concerned with the earth's orbit or the earth's position in any way, but only with the relative position of Jupiter and the sun with reference to the fixed sidereal first point of Mēsha. To apply the parallax as advised is certainly wrong from a consideration of the true system of the universe, and apparently would be equally wrong even from a Hindū point of view.

If the application of half the parallax were omitted from Mr. Dikshit's process at this stage, the greatest difference in the result would be about half a degree.

The next process, after having found Jupiter's anomaly, is to find from it the proper equation of the centre; and, deducting this from Jupiter's mean longitude and from the "first commutation," V, to obtain Jupiter's heliocentric longitude, X, and the "second commutation," Y. Mr. Crommelin states that there has been omitted from this operation the application of the sun's equation of the centre to the sun's longitude, which is necessary in order to find his true longitude (the important point here) from his mean longitude as already found. The greatest solar equation of the centre is about 2° 10′ 33″.

184A. With this preface by way of warning, I proceed to explain in detail Mr. Dikshit's system for finding Jupiter's true or apparent longitude.[1]

(i.) First find the mean longitudes of Jupiter and the sun as directed above.

[1] The apparent longitude of a planet in Hindū astronomy is its actual angular distance from the fixed first point of Mēsha, measured along the ecliptic. Its mean longitude is this calculated angular distance as it would be if the planet moved with an unvarying or mean velocity.

(ii.) Subtract the sun's mean longitude from that of Jupiter. Call the result "V." If V is more than six signs subtract it from twelve signs and use the remainder for the next process.

(iii.) With V or this remainder as argument find the parallax[1] by Table XXXV. below. Parallax is *minus* when V (not the "remainder," but V itself) is not more than six signs, *plus* when it is more than six. Apply half the parallax to the mean longitude of Jupiter, and subtract from the sum the longitude of Jupiter's aphelion as given, for some of the *Siddhāntas*, at the foot of Table XXXV. The remainder is the anomaly.[2] If it is more than six signs subtract it from twelve signs and use the remainder. Call the result "W."

(iv.) With W as argument, find the equation of the centre[3] by Table XXXV. This is *minus* when W is not more than six signs, *plus* when it is more than six. For ordinary purposes the equation may be taken by whole degrees; *e.g.*, if W is less than 149° 30′, take the equation for 149°; if it is more than 149° 30′ take the equation for 150°; and so with parallax. If great accuracy is necessary the intervals may be divided proportionately. Apply the equation of the centre to the mean longitude of Jupiter and the result is the heliocentric longitude.[4] Call this "X."

(v.) Apply the equation of the centre, plus or minus, to V. If the result is more than six signs subtract it from twelve signs and use the remainder. Call the result "Y."

(vi.) With Y as argument, find the parallax by Table XXXV. (*minus* or *plus* as in (iii.)). Apply it whole to X, and the result is Z, Jupiter's apparent longitude as required.

185. I take the example given at p. 156 of the *Indian Calendar*. We want to know the position of Jupiter at mean sunrise on a day corresponding to March 12th, A.D. 1215. The full working for Jupiter's and the sun's mean longitude at that time is given in Example 61 below, and I need not here repeat it. I use for process (i.) the figures there found, according to the *Ārya Siddhānta*—

(i.) Jupiter's mean longitude = 10 s. 17° 56′ 48″, and that of the sun 11 s. 14° 45′ 28″. We now work for Jupiter's apparent longitude by the rule given.

(ii.) We subtract the sun's mean longitude from that of Jupiter, adding twelve signs (= 360°) to the former to enable us to do so.

	s.	°	′	″	
	22	17	56	48	
	— 11	14	45	28	
V =	11	3	11	20	= first commutation.

This being more than six signs we use for the next process the remainder from twelve signs.

s.	°	′	″
12	0	0	0
— 11	3	11	20
	26	48	40

[1] Parallax, in its ordinary sense, is the difference between the direction of a celestial object as observed from the earth's surface and its direction as it would be observed from the centre of the earth; or the angle subtended at the object by that radius of the earth which is drawn from the centre to the observer. When the object is in the observer's zenith parallax is nil. It is greatest when the object is in the observer's horizon. Another sense in which the word parallax is used by astronomers represents the apparent shift of a heavenly body due to the earth's movement round the sun; and in this sense parallax is the angle subtended at the body in question by the line joining the earth and the sun at the time. For distinction this is often referred to as "annual parallax," and it is this latter with which we are concerned in finding the true place of a planet.

[2] For definition of "anomaly" see *Indian Calendar*, p. 5, n. 4.

[3] For definition of "equation of the centre" see *ibid*, p. 60, § 107.

[4] The heliocentric longitude of a planet is its longitude as seen from the sun; or the angle formed by lines drawn (i.) from the sun to the fixed first point of Mēsha; (ii.) from the sun to the point where a great circle passing through the pole of the ecliptic and the planet cuts the plane of the ecliptic.

(iii.) Parallax for 27° is (*Table XXXV.*) 4° 20′. V being more than six signs this is additive. We therefore add half to the mean longitude of Jupiter.

	s.	°	′	″	
	10	17	56	48	
+		2	10	0	
	10	20	6	48	
Subtract . . .	6	0	0	0	Long. of Jupiter's aphelion by the *Ārya Siddhānta*.
W =	4	20	6	48	= Jupiter's anomaly.

(iv.) 4 s. 20° = 140°. Equation of centre for 140° (*Table XXXV.*) = 3° 25′. W is less than six signs, and therefore the equation is subtractive. It has to be subtracted from the mean longitude of Jupiter.

	s.	°	′	″	
	10	17	56	48	
—		3	25	0	
X =	10	14	31	48	= Jupiter's heliocentric long:

(v.) Deduct the same equation of the centre from V.

	s.	°	′	″	
	11	3	11	20	
—		3	25	0	
Y =	10	29	46	20	= second commutation.

This is more than six signs and is therefore deducted from twelve signs.

	s.	°	′	″
	12	0	0	0
—	10	29	46	20
	1	0	13	40

(vi.) Parallax for 1 s., or 30° (*Table XXXV.*) = 4° 49′. This has to be applied to X, and because X was in this case more than six signs it is additive.

	s.	°	′	″	
	10	14	31	48	
+		4	49	0	
Z =	10	19	20	48	= Jupiter's apparent longitude.

We have therefore determined that at mean sunrise on March 12th, A.D. 1215, or the 18th Mīna of K.Y. 4315 expired, the apparent longitude of Jupiter was 10 s. 19° 20′ 48″, or 319° 20′ 48″. By Table XXII. we find that, by his apparent longitude as well as by his mean longitude Jupiter was then in the sign Kumbha.

186. I have tested by the present method a date published by the late Professor Kielhorn (*Ind. Ant.*, XXV., 1896, *p.* 174, No. 16) of the Kollam era in South India. The date and time correspond to noon on April 3rd, A.D. 1607, or the 6th Mēsha, K.Y. 4708 expired, and he found that at that moment Jupiter's mean place was 11 s. 5° 55′, and his true place was 11 s. 9° 16′. By Mr. Dikshit's method, and using the *Sūrya Siddhānta*, I find Jupiter's mean place to have been 11 s. 5° 56′ and his true place 11 s. 9° 22′. The difference between us is only 1′ in mean and 6′ in true longitude. I am not aware how Professor Kielhorn worked in order to obtain his results, but I conclude that in all probability he calculated by the system published by him in the *Indian Antiquary*, Vol. XVIII. (1889), pp. 193 ff., 380 ff.

187. The general reasons for the adoption of the above process will be better understood after a short explanation. We have to find the apparent longitude of Jupiter as seen from the earth at the given moment. It is easy by our Tables to determine for any moment the mean longitude of Jupiter

and the mean longitude of the sun. Deducting the latter from the former we have our "V," *i.e.*, the angular distance of mean Jupiter from mean sun. The true heliocentric longitude of one of our planets, or his longitude as seen from the centre of the solar system, is his mean longitude plus the equation of the centre; and the latter is calculated from his mean anomaly, which is dependent on his perihelion point. (*Indian Calendar, p.* 5, *n.* 4.) Since this point is separated by exactly 180° from the aphelion point we subtract the longitude of the latter from Jupiter's found mean longitude and thus obtain his angular distance in mean longitude from the perihelion point, which is the required mean anomaly, "W." From the mean anomaly thus found we find by the Table the proper equation of the centre, and, applying it to Jupiter's mean longitude, find his true heliocentric longitude, "X." But this is his position as seen from the sun, and to obtain the same as seen from the earth, which daily shifts its position, we have to apply the proper equation for parallax. Mr. Dikshit's principle is to find the proper parallax by applying the equation of the centre to the angular distance of mean Jupiter from mean sun (our "V"), the operation resulting in his "second commutation" (our "Y"); and thence calculating the parallax by the Table. Applying this parallax to "X," the heliocentric longitude of Jupiter as found, he finds the required apparent longitude of Jupiter at the given moment as seen from the earth.

As I have already stated, Mr. Crommelin takes exception to portions of Mr. Dikshit's system.

NOTE ON THE PREPARATION OF TABLE XXXVIII.B.

Continuation of Table I. of the Indian Calendar to A.D. 1950.

188. This Table, prepared to meet contingencies of the present day, carries on all the details of Table I. of the *Indian Calendar*, which ended with A.D. 1900, to the year 1950. To preserve complete continuity and prevent confusion it is calculated precisely in the same way as the former. That is to say, cols. 8 to 12 and 19 to 25 are computed by the *Sūrya Siddhānta* with the bīja, the European dates being, of course, in New Style.

189. For the times of apparent Mēsha saṁkrāntis the figures for cols. 13 to 17A were separately calculated, for the *Ārya Siddhānta* by the annual increment, and for the *Sūrya Siddhānta* after conversion of the former by use of the Table on p. 55 of the *Indian Calendar*; every result being checked by reference to the figures of the year removed from it by an interval of 576 years. (§ 47 *above*.)

190. The next process was the calculation of the beginning of the luni-solar year, cols. 19–25. We have to find the *a*, *b*, *c* for sunrise on the civil day following the moment of the new moon next later than the moment of apparent Mīna saṁkrānti in each year. (*Cols.* 13–17*a*.) Professor Jacobi has given us the increment in *a*, *b*, *c*, for a century as $a = 1468.7$, $b = 450$, $c = 2.4$,[1] but this is for an ordinary century. In the present case, the year A.D. 1900 not having been a leap-year the figures must be increased by the value of a day, viz.: $a = 339$, $b = 36$, $c = 3$, and they amount to $a = 1808$, $b = 486$ $c = 5$. Taking any year, therefore, we first note the entries in cols. 19 to 25 for a year exactly a century earlier, and calculate from this, by adding the figures for the number of days intervening between the date in col. 19 and the date on which Mēsha saṁkrānti occurred in the given year.[2] This gives us the condition of the moon on that last date, but a century earlier. Then, by deducting two days from the week-day and 1808, 486 and 5 respectively from the *a*, *b*, *c* so found, we find the condition of the moon on the day of apparent Mēsha saṁkrānti in the given year. This done, we add equation *b* and equation *c* to *a*, and by Table VIII. discover what tithi was current at that sunrise. This arrived at, we know that the

[1] *Indian Antiquary* XVII., pp. 159–160.

[2] This is the most convenient way, as we have fixed in Table I. the moment of each Mēsha saṁkrānti. It is only necessary to bear in mind that when the lunar month Chaitra is itself intercalated the luni-solar year begins a month earlier.

new-moon that marks the beginning of the luni-solar year was the new-moon at the beginning of the lunar month to which that tithi belongs[1]; and as we only want the *a*, *b*, *c* at mean sunrise of the day immediately following that new-moon we deduct from the *a*, *b*, *c* of the Mēsha saṁkrānti day, already obtained, the figures for the whole days corresponding to the interval from the beginning of the lunar month to the tithi current on the day of Mēsha saṁkrānti. This gives the day, and its *a*, *b*, *c*, &c., at mean sunrise, on which the luni-solar year began, or the day corresponding to Chaitra śuklā 1st in the given year.

191. After this calculation was completed, in every case I checked it by Prof. Jacobi's Tables 5, 6, 7. (*Indian Antiquary, XVII., p.* 164.) For this purpose I had to find the proper century-figure (in Table 6) for the twentieth century, since his Tables end with the end of the nineteenth century. They are: (*a*) 10,000 — 1808, (*b*) 1000 — 486, (*c*) 1000 — 5; or *a* = 8192, *b* = 514, *c* = 995. These figures are approximate, decimals being excluded, but they are as accurate as the rest of Table 6.

For an example I take the year A.D. 1901:—

			w.	*a.*	*b.*	*c.*
Table I. for A.D. 1801 (cols. 19-25) . . .	15 March (74)		1	9858	215	205
In 1901 Mēsha saṁkrānti was on April 12th.						
Add (*Table IV.*)	28	(28)	0	9482	16	77
1801 April 12th		(102)	1	9340	231	282
Century difference			—2	—1808	—486	—5
1901 April 12th, Friday			6	7532	745	277

a (= 7532) plus equation *b* (= 0) and equation *c* (= 1) gives *t* = 7533, which (*Table VIII.*) shows that the 8th krishṇa tithi was current. We therefore deduct 22 days to arrive at the figures for Chaitra śukla 1st, the first civil day of the luni-solar year.

	d.		*w.*	*a.*	*b.*	*c.*
	12 April	(102)	6	7532	745	277
For 22 days (*Table IV.*)	— 22	— 22	— 1	— 7450	798	60
Sunrise on Chait. śuk. 1st in A.D. 1901 .	21 March	(80)	5	82	947	217

Check this by Jacobi's Tables 5, 6, 7.	*w.*	*a.*	*b.*	*c.*
(*Table* 6) 20th century (*Table XXXIX. below*)	5	8192	514	995
(*Table* 5) year (190)1	5	5138	566	6
(*Table* 7) 21st March	2	6752	867	216
(Thur.)	5	82	947	217

The results agree, and the entry is made accordingly for Table XXXVIII.

With *a*, *b*, *c* as given we find *t* = 177 = (*Table X.*) 12 h. 32 m.; but continuing the calculation for absolute accuracy it works to 11 h. 20 m. New moon therefore took place according to the *Sūrya Siddhānta* 11 h. 20 m. before mean sunrise on March 21st, or at 6.40 p.m. on March 20th, A.D. 1901. By modern European science it occurred at 0.53 p.m., or 53 m. past noon on that day at Greenwich; or for the meridian of Laṅkā at 5.56 p.m.

192. The next process was the computation of the added (adhika) lunar months by the *Sūrya Siddhānta*. I have stated in para. 190 that for other purposes I had ascertained the state of the moon at mean sunrise of the day on which apparent Mēsha saṁkrānti occurred in each year, given in terms of *a*, *b*, *c*. We have only to add to this the *a*, *b*, *c* for the hours and minutes after mean sunrise on that day as given in col. 17A, and we have the condition of the moon at the actual moment of apparent Mēsha saṁkrānti. The values of *a*, *b*, *c* for the several intervals between that moment and each subsequent saṁkrānti in the year are given in Table XVIII.B; and by this the calculation was made in the ordinary

[1] Except when Chaitra is intercalary, in which case the *previous* new-moon was the first of the year.

way. The work shows that there was no suppression of a lunar month during the period 1901 to 1950 A.D., and since (*Indian Calendar, foot of p.* 29) it had been already determined that in all probability there would not be a suppression till 1944, the discovery that there will be none in that year renders it practically certain that there will be none till A.D. 1963, viz., after 141 years have elapsed since the last suppression.

THE LAGNA.

193. Owing to the diurnal revolution of the earth on its axis a meridian on the earth's surface passes once in every 24 hours completely round the circle of the 12 solar signs and 27 or 28 nakshatras (§ 113 *&c.*); and therefore, roughly, the meridian is within one of the solar signs for two hours every day. As the meridian sweeps round, the first point of each solar sign meets it, or cuts it, at about two-hour intervals during the day. This gives rise in Hindū astronomy to calculations made both as to what sign was the lagna at a particular moment of a day, and as to the exact time at which a particular sign or part of a sign became lagna. The word *lagna* means literally "intersecting," "meeting," "coming in contact," in astronomy the cutting of one line or great circle by another; and its most common astronomical use is to designate that point of the ecliptic which at a given time is on the eastern horizon. At other times it designates the point of the ecliptic at a given time on the meridian. The horizon lagna is called *kshitijē lagna*, the meridian lagna is called *madhya lagna*. Since the solar sign remains in contact with the horizon or the meridian for about two hours each day it is clear that if a date of an inscription, besides giving us the civil day, month and year, mentions that a certain sign was lagna, we learn to within about two hours the exact time of day when the action referred to in the inscription was performed. It is as if a European inscription should state, besides the date, that the time referred to was "between 10 a.m. and noon."

194. Professor Kielhorn told us (*Indian Antiquary, Vol. XXV.* (1896), *p.* 291) that, up to the time of writing, the earliest inscription known to him, bearing a Śaka date and from a genuine Indian inscription, in which the lagna occurs is one of Ś. 867 expired, A.D. 945. It is an Eastern Chalukya inscription of December 5th, A.D. 945, recording the accession of King Amma II. (*Ind. Ant., Vol. XXIII.* (1894), *p.* 123, *No.* 62). Mention of the lagna has, however, been found earlier than this in Cambodia.

195. Now I do not propose to devote any great space to the consideration of the problem of the lagna, for two reasons. The first is that Professor Jacobi, in his paper entitled "*How to calculate the lagna,*" in the *Indian Antiquary* for July, 1900 (pp. 189–90), has given us full and ample rules for solving the problem by use of his own Tables, and to attempt here to reproduce those rules would be merely to trespass wantonly on his ground. The second is that, although undoubtedly the superstitious Hindū paid at one time and another great attention to the point, the lagna is really not a matter which greatly concerns an historian. When we are perfectly certain of the accuracy of a civil day as given in any record, it is very seldom of any consequence to us to enter into particulars as to any given hour of that day.

196. It will, therefore, I think, be sufficient if I show how to obtain a first approximation to the correct result, leaving extreme accuracy to be arrived at by use of Jacobi's own method and Tables. This approximation, which, so far as I can judge, was considered sufficient by Kielhorn, can be obtained from the *Indian Calendar* and the Tables in the present volume.

197. On the supposition that the earth's equator and the ecliptic are on one and the same plane, in order to find at what time a given sign, or part of a sign, becomes lagna, or rises on the eastern horizon, we have only to find (i.) the true longitude of the sun at mean sunrise on the given day; (ii.) the distance of the sun at that moment from the given lagna, measured along the ecliptic; (iii.) the time required for covering this distance. The result will be approximately, and without reference to the

inclination of the ecliptic or to the terrestrial latitude of the observer, the time of the lagna measured from mean sunrise. This is the first approximation, at which alone I aim in the present section.

198. I take the example worked out by Jacobi, *i.e.*, the 6th solar day of Jyēshṭha, K.Y. 4000 expired, the given lagna being the 15th degree of Kanyā, and calculation being made for the horizon lagna. The work is to be done by my own processes. First we require the true longitude of the sun. This is the "*s*" of our calculations for the nakshatra (§ 119 *above*), the formula for finding the value of which is, in the *a, b, c* system, $(c \times 10) + 7207$ — equation *c*. To find *c*, and therefore equation *c*, we take the *a, b, c* for the first civil day of Chaitra at mean sunrise as given in Table I; add to this the *a, b, c* for the interval of days to the given day, and so find the *c* for mean sunrise of the given day. Use the *First Ārya Siddhānta*.

K.Y. 4000 expired was = A.D. 899–900. By Table I., cols. 13, 17, Mēsha saṁkrānti occurred on day 81, at 13 h. 47 m. By the general rules, therefore (§ 43), the first civil day of solar Vaiśākha, the first month, was day 82. The 6th day of the second month, Jyēshṭha, was 36 days later, or day $(82 + 36 =)$ 118. We have the value of *c* on the 75th day given us in col. 25 of the same Table, viz., $c = 261$. $118 - 75 = 43$. We add, therefore, from Table IV., the value of *c* for 43 days, viz.: 118, and we find that *c* on the 118th day $= (261 + 118)$ 379; and therefore equation $c =$ (*Table VII.*) 19. Using the formula $(c \times 10) + 7207$ — equation *c*, we find $s = 978 =$ (*Table VIII.B*) 35° 14′. This is (i.) the apparent longitude of the sun at mean sunrise on the given day.

(ii.) The longitude of the given lagna, viz., of the 15th degree of Kanyā, was, by Table XXII., 165°. As the sun's longitude was 35° 14′ at mean sunrise, the distance between the true sun and the lagna was (165° — 35° 14′) 129° 46′.

(iii.) We turn this distance into time by calculating at the rate of 4 m. to a degree and 4 s. to a longitudinal minute, and we find that the 129° 46′ take in rising 8 h. 39 m. 4 s.

Hence we have found that roughly (holding the equator and ecliptic to be in one plane and taking no account of the terrestrial latitude of the place) the 15th degree of Kanyā rose on the day in question at 8 h. 39 m. 4 s. after mean sunrise. Jacobi gives the result by his first approximate process as 21 gh. 40 vin., or 8 h. 40 m.

(*See also Example* 63 *below.*)

HINTS.

By the	d.	gh.	p.	v.	pra.	d.	h.	m.	s.	Decimals.
	1. *Length of the mean sidereal solar year.*									
1st *Ārya Siddhāntas*	365	15	31	15	0	365	6	12	30	365·258680555
Present Sūrya Siddhānta	365	15	31	31	24	365	6	12	36·56	365·258756481
Modern science			—			365	6	9	9·29	365·256357523
	Length of the lunar synodic year.									
Sūrya and *Ārya Siddhānta*	354	22	1	23	57	354	8	48	33·58	354·36705535
Modern science			—			354	8	48	33·64	354·367056
	Length of a mean solar month or one-twelfth of a sidereal year.									
Ārya Siddhānta	30	26	17	36	15	30	10	31	2·5	30·438223379
Sūrya Siddhānta	30	26	17	38	0	30	10	31	3·05	30·438229707
Modern science			—			30	10	30	45·77	30·438029794
	Length of a mean lunar synodic month.									
Sūrya and *Ārya Siddhāntas*	29	31	30	7	18	29	12	44	2·79	29·530587946
Modern science			—			29	12	44	2·86	29·530588715
	Length of a mean tithi.									
Sūrya and *Ārya Siddhāntas*	0	59	3	40	14	0	23	37	28·09	0·984352931

2. In the *a, b, c* system, adopted by Prof. Jacobi in the *Indian Antiquary*, Vol. XVII., and by us in the *Indian Calendar* and in the present volume, we find a final value, after calculation, in terms of *t* or lunation-parts, each of which is $\frac{1}{10000}$th of a mean lunation. This is converted into time by Table X., which gives the value of *t* (or *n* or *y* or, in mean calculations, of *a*) in mean time. Each unit of *t*, or in mean calculations of *a*, is on an average 4.25 minutes, so that $t = 4$ means 17 minutes But actually the time value of $\frac{1}{10000}$th of an apparent, or true, lunation constantly varies. It is therefore only possible to tabulate for mean time. The value of *t* arrived at by the first process of calculation (*see working on p.* 81, *Ind. Cal.*) is approximate. When the processes are continued the final result is accurate. In the case of mean added months the value of *a* (which then $= t$) is at once absolutely accurate. (*Ind. Cal.*, § 82, *p.* 50.) But when these values are converted into time by Table X. the result is in mean time. For conversion to true time, for the latitude of the place and for the time of year, see Prof. Jacobi's article in *Epigraphia Indica*, Vol. II., and Tables F and G of my *Eclipses of the moon in India.*

True and mean time.

3. Since the processes recommended in this work compel us to add together figures representing whole units, in the case of which fractions below half are ignored, it sometimes happens that one element a little too large cancels the irregularity of another a little too small; it also sometimes happens that the total is one unit too small or too large, rarely two. Every very close or doubtful case should therefore be freshly examined by Prof. Jacobi's "Special Tables" in the *Epigraphia Indica*, Vol. I.

Small differences in calculations.

4. The Tables in this work are principally concerned with the *First Ārya Siddhānta* and *Present Sūrya Siddhānta.* As to the dates from which these authorities came to be relied on by the framers of Hindū almanacs, and to the parts of India in which their use became prevalent, *see* §§ 4, 6–13A, and generally in the Text above. The Tables are not, unless specially so mentioned, to be relied on for calculation by other authorities or for other times and places.

The Siddhāntas.

5. Calculations by the *true* or apparent motions of the sun and moon must always begin, for solar dating, from *true* Mēsha saṁkrānti; and by the *mean* motions from *mean* Mēsha saṁkrānti. Similarly, for lunar dating, calculation by true lunar months and tithis must begin from the first true new-moon of the year, and by mean lunar months and tithis from the first mean new-moon of the year.

True and mean calculations.

6. When calculating by *mean* intercalations of lunar months Table XXIV. must be used. It takes the place of Table I. for the *a, b, c* and date of the first civil day of the luni-solar year in the case of a year which does not contain a mean intercalation, but which immediately follows a year which does contain one and in which there was no "true" intercalation.

Table XXIV.

7. No suppression of a lunar month seems to be possible except in the case of a year separated by one of the following intervals of years from a year which contained a suppressed month: 19, 38, 46, 65, 76, 122, 141.

Suppressions of lunar months.

8. Table I., cols. 8 to 12, *Indian Calendar*, contain the calculations for intercalations and suppressions of lunar months by the *true* or *apparent* system; cols. 8A to 12A contain the same by the mean system, of months; calculated, that is, in the first case by the true motions of the sun and moon, and in the second by their mean motions. (*For the meaning of "lunation-parts" see Arts.* 80, 81, *pp.* 49, 50.) All these are calculated according to the *Sūrya Siddhānta.* If results by the *First Ārya Siddhānta* are required, they must be converted by the rules and examples given. The *a, b, c* entries given in cols. 23–25 are the same by both these authorities.

Conversion of results for intercalations and suppressions of lunar months.

10. In the *Indian Calendar*, p. 154, § 160 (*b*), we gave a list of points to be remembered in verifying dates, remarking that that list was not exhaustive. Let the following be added as A (I.) (*c*): "The original date may have been calculated by mean months." The present work shows how to calculate them.

Addition to Ind. Cal., § 160(*b*).

12. When a saṁkrānti is found to take place within about ($t =$) 33 lunation-parts of the moment of new-moon, the use of a different Siddhānta may cause the intercalation of a month next preceding or next following the one found to have been intercalated by the calculation. When, therefore, the results for the moments of two consecutive saṁkrāntis connected with a lunar month are both less than ($t =$) 9967 or both greater than ($t =$) 33 it may be assumed that the same month was intercalated by all Siddhāntas. (*Ind. Cal., p.* 29, *note* 1, § 88, *p.* 51). Where, however, a Siddhānta has been used with a bīja-correction, the limits must be enlarged to 113 lunation-parts, or $t = 9887$ and 113.

Saṁkrāntis. Limit of differences.

13. (i.) When working for "true" intercalations and suppressions of lunar months the equations of (*b*), the moon's mean anomaly, and (*c*), the sun's mean anomaly, are added to the *a* found by the calculation. It is convenient to note that no *a* can possibly increase by these additions to as much as 10,000 or 0, the moment of new-moon, if it (*a*) is less than 9599, since the greatest possible increase caused by the addition of these equations is ($280 + 121 =$) 401. (*See Tables VI., VII., col.* 2.) If the *a*, therefore, of both the saṁkrāntis concerned is near to but less than 9599, the month must be a common one.

Intercalations and suppressions of lunar months. Limitations.

(ii.) Similarly there can be no intercalation or suppression of a lunar month in a year the "*a*" of whose Mēsha saṁkrānti is less than 5910, since the greatest increase of *a* in a year (*see Tables XVIII., XIX.A and XIX.B*) is 3689, which, + 401 (*above* 13 (i.)), = 4090; and 10,000 — 4090 = 5910.[1]

14. No mean intercalation is possible in a year in which the *a* of mean Mēsha saṁkrānti is less than 6311, since the greatest increase of *a* for any mean saṁkrānti of a year is 3689. 10,000 — 3689 = 6311.

15. In connecting tithis with solar days note that—in consequence of (i.) the chance that a Siddhānta has been used by the almanac-maker different from that by which the calculation is being made, (ii.) the difference between the mean time of Table X. and the possible true time of the date, (iii.) the difference at the principal place in the neighbourhood of the inscription, where probably the almanac-makers resided, of the time of true and mean sunrise (which last is the basis in our system)—a result which shows a certain tithi, nakshatra, or karaṇa as beginning or ending within about 5 ghaṭikās, or 2 hours, of sunrise may be wrong by one day. Consequently, whenever, in a calculation for mean sunrise made by our Tables, the tithi-index (t) or the nakshatra-index (n) or the karaṇa-index (*Table VIII., cols.* 3, 8, 9, 10) is within 30[2] of the beginning-index or ending-index of the tithi, nakshatra, or karaṇa, it is possible that the result may be one day wrong. In the case of the yōga the limit may extend to 7 ghaṭikās, or 2 h. 48 m., or, in terms of the yōga-index, 50. These limits are not fixed; but when the result ascertained is not within, or almost within, those limits it is safe to conclude that the result would be the same whatever Siddhānta might have been used, and whether the original calculators had worked by true or mean sunrise, and by true or mean time. When a doubt exists the date should be tested by Jacobi's *Epig. Ind.*, Vol. I., Special Tables. (*See Ind. Cal.*, § 37, *pp.* 20, 21.)

Tithis, nakshatras and karaṇas. Limitations.

[1] If, however, this "*a*" is less than about 330 an intercalation of Chaitra is possible.

[2] In mean-time 2 h. 8 m. (*Table X.*)

Tithis.

16. *Adhika* and *kshaya tithis.* A day on which no tithi ends, and a day on which two tithis end is considered inauspicious. Such was the case on Wednesday, September 12th, A.D. 1894, and Friday, September 21st, in the same year, as shown in the Pañchāṅg extract on p. 14 of the *Indian Calendar*. (*See Example* 23.)

When the tithi-index of a sunrise is found to be within ($t =$) 40, either way, of the ending-point of a tithi (*Table VIII.*), and when equation b is decreasing, either that tithi or another close to it is adhika, shortly after or before the sunrise in question; and when equation b is increasing a tithi, different from the one in question, is kshaya shortly before or after the sunrise. (*Ind. Cal.*, § 142, *p.* 78.)

Note that the intercalation or expunction of a tithi only affects the question as to the number of the tithi current at a certain sunrise. The tithis themselves always run their regular course, 1 to 15. There is, for instance, no number 16 given to a tithi. The regular currency of each tithi is unaffected by the nomenclature given to the civil day in consequence of the tithi which is found to be current at its sunrise.

When new-moon exactly coincides with a saṁkrānti.

18. In work for intercalations and suppressions of lunar months cases are sometimes found where a new-moon appears to occur precisely at the moment of a solar saṁkrānti, in other words that the moment of new-moon and the moment of the sun's entry into a sign are identical; and the question has to be decided whether the moon is to be considered as waxing or waning at that moment, since upon that decision depends the intercalation or suppression of the lunar month concerned. For instance, in K.Y. 4257 current, at the Kumbha saṁkrānti, the moon was found, according to the *Sūrya Siddhānta*, to be waning, t being 9851, and at the next saṁkrānti, Mīna, t being found = 10,000 or 0, the question is whether the month connected with those two saṁkrāntis, viz., lunar Phālguna, was intercalated or common. If at the Mīna saṁkrānti the moon was considered to be still waning, Phālguna would be a common month; but if it was considered that she had just passed the moment of new-moon and had begun to wax, Phālguna would be an intercalated month. My collaborator in the *Indian Calendar*, who was undoubtedly thoroughly acquainted with Indian custom, decided that in such cases it must be held that the 0-point is as it were included within the scope of the period preceding it; it marks the climax of that period; so that at the point itself a new period has begun. In the case of a waning moon where new-moon is found, after full calculation, to occur at the very instant of a solar saṁkrānti, the latter is included in the period of wane; the saṁkrānti is at the climax of the wane; and at the 10,000- or 0-point of the moon's age a new-moon has actually begun. Therefore in the case alluded to Phālguna was, because the moon had begun to wax at the Mīna saṁkrānti, decided to have been an intercalated month. In stating the ($t =$) 0 of col. 11 in terms of the tithi for col. 12 of Table I. we showed the moon as actually waxing by entering the tithi-value at the moment of the Mīna saṁkrānti as 0.001. This was done in all such cases.

For every such case special and careful calculation should be separately made by Jacobi's *Epigraphia Indica*, Vol. I., Special Tables, when it will generally be found that the moon was certainly either waning or waxing at the exact moment of the saṁkrānti. But in the exceptional case, after all tests, of an exact concurrence of the lunar and solar phenomena, the case would be best decided on Mr. Sh. B. Dikshit's principle; the calculator bearing in mind at the same time the possibility of a different

practice being prevalent at different parts of India or at different times, so that a different lunar month might have been intercalated or suppressed by other Hindū almanac-makers. The principle applies equally, of course, in the case of suppressions of months; if at the first saṁkrānti t is found, after the most careful calculation, to be scientifically 0, then the new moon has begun, and if at the next saṁkrānti that moon is found to be waning the lunar month included is suppressed; if still waxing it is common.

I imagine that the same principle would apply to the case of tithis, nakshatras, yōgas and karaṇas.

Expunction of Jovian saṁvatsaras. Limitations.

19. *Expunction of Jovian saṁvatsaras in solar years.* There can be no expunction of a saṁvatsara in a cycle the Prabhava at the beginning of which (*Tables XXVII., XXVIII., &c., col.* 3) took place later than, in the case of the—

Sūrya Siddhānta, without the bīja	253.92212712	days
Sūrya Siddhānta, with the bīja	253.44632502	
First Ārya Siddhānta	254.15996748	
Original Sūrya Siddhānta	253.92212712	
Brāhma Siddhānta	254.30580264	
Siddhānta Śirōmaṇi		
Second Ārya Siddhānta	253.90316838	

after apparent Mēsha saṁkrānti; for the greatest day-figure in Table XXVII.A, XXVIII.A, &c., col. 3, is that which in each case appertains to the last saṁvatsara, 60 Kshaya, of the cycle; and the difference between this day-figure and the day-figure of the No. 1 Prabhava of the next cycle is the exact amount of the difference between the length of the solar year and the Jovian saṁvatsara by the different authorities. If any cycle, for instance, began, according to the *Sūrya Siddhānta* without the bīja, by the smallest fraction later than 253.922127120 after apparent Mēsha saṁkrānti of its solar year, then it is evident that the next saṁvatsara must begin *after* the next apparent Mēsha saṁkrānti, and therefore that the preceding cycle had completed itself without any expunction having taken place in it. 253.922127120 minus (*Table XXVII.A, col.* 3, *for* 60 *Kshaya*) 249.690091668 = 4.232035452[1] = the difference between the length of the solar year and the Jovian saṁvatsara by the authority used. And so with the rest.

20. It is sometimes important, when making calculations in which the exact moment of a true Mēsha saṁkrānti is an essential element, to know the number of seconds as well as the number of minutes of the time of its occurrence; minutes alone being given in col. 17 of Table I., along with the day and hour. Of the importance of this knowledge Examples 5 (*b*) and 6 (*c*) will serve as proof. For the *Ārya Siddhānta* we can always ascertain the exact time by applying the following rule: *When the number of the current K.Y. year, or the year A.D., is even, the minutes entered in col.* 17 *of Table I. are whole minutes. When the number of the current K.Y. year, or the year A.D., is odd,* 30 *seconds added to the time entered in col.* 17 *gives the exact time. If working with ghaṭikās, &c., the amount to be so added in col.* 15 *is* $1\frac{1}{4}$ *palas.* The exact time according to other Siddhāntas can be obtained from this basis, by the rules given in this volume.

The reason for this rule is to be found in the fact that, as shown in § 162 above, mean Mēsha saṁkrānti of the year A.D. 499, K.Y. 3601 current, took place according to the *Ārya Siddhānta* exactly at noon, or at 6 h. 0 m. Laṅkā time on March 21st. The śōdhya by that authority being 2 d. 3 h. 32 m. 30 s., we know that the moment of true Mēsha saṁkrānti of that year was March 19th at 2 h. 27 m. 30 s. The *Indian Calendar*, in col. 17 of Table I., tabulates only the whole minutes and states the time as 2 h. 27 m. If 30 seconds be added to this tabulated time we have the exact time. The length of the year by the *Ārya Siddhānta* being greater by 12 m. 30 s. than that of the Julian year (*Table XXXVII.*,

[1] The "F" of § 142 &c.

col. 3, *below*) we tabulated in col. 17 of Table I. by intervals of alternately 12 m. and 13 m. in order to avoid the use of seconds; so that while in one year the tabulated time is too early by 30 seconds, in the next it is correct. Thus while the actual moment of true Mēsha saṁkrānti in A.D. 499, K.Y. 3601 current, was 2 h. 27 m. 30 s. (but "2 h. 27 m." in Table I.), the actual moment in A.D. 500, K.Y 3602 current, was (2 h. 27 m. 30 s. + 6 h. 12 m. 30 s. =) 8 h. 40 m. exact (the same in Table I.). This rule holds good for all years A.D., both before and after, A.D. 499 the tabulated time being correct in one year and subject to an addition of 30 seconds in the next.

[Note that in years B.C., owing to the fact that 1 B.C. immediately precedes A.D. 1, a current year of the K.Y. with an even number corresponds to a year B.C. with an odd number; and *vice versa.* Therefore for years B.C. the time of true Mēsha saṁkrānti (found by use of Table I., col. 17, and calculated backwards as directed in this work) is in *whole minutes* in *odd years B.C.* (current even years K.Y.); but, to be accurate, must have 30 *seconds added* in *even years B.C.* (current odd years K.Y.). Table XXXVIII.A gives the times of Mēsha saṁkrānti back to 59–58 B.C. on the same principle as in Table I., and its tabulated times can be made absolutely accurate to the second by application of this rule to the figures given in col. 17.]

EXAMPLES.

Solar Reckoning.

Mēsha saṁkrāntis.

Example 1.—*The moment of true sidereal Mēsha saṁkrānti according to the Ārya Siddhānta being found from Table I. of the "Indian Calendar" for any year for which the same moment according to the Sūrya Siddhānta is not given, it is required to find the latter.* For each year from K.Y. 3401 expired, A.D. 300–1, to K.Y. 4201 expired, A.D. 1100–1, the moments of occurrence of true sidereal (nirayaṇa) Mēsha saṁkrānti according to the *Ārya Siddhānta* are given in Table I., cols. 13 to 17; and according to both the *Ārya* and *Sūrya Siddhāntas* from the latter date to K.Y. 5001 expired, A.D. 1900–1. Example 1 shows how to find the *Sūrya Siddhānta* true Mēsha saṁkrānti for any year in the former period.

Rule. Take down the time according to the *Ārya Siddhānta* from cols. 13 to 17 of Table I., and convert it to *Sūrya Siddhānta* time by Table XVII. (§§ 44 i, 46). (*See above "Additional Notes," II., p. xii.*)

Wanted the moment of Mēsha saṁkrānti by the *Sūr. Siddh.* in K.Y. 3915 expired, or A.D. 814.

	d.	*w.*	*h.*	*m.*
By Table I., cols. 13 to 17	21 March (80)	3	14	5
By Table XVII.				+ 35
Answer. M.S.[1] by *Sūr. Siddh.*	= 21 March (80)	3 Tues.	14	40

If the time is required in ghaṭikās and palas, the answer would be — (from Table I., col. 15) 35 gh. 12 p. + (35 m. converted to gh. and p. by Table XXV.) 1 gh. 27½ p. = 36 gh. 39½ p. [*Calculation in terms of ghaṭikās and palas will not be specially dealt with in these examples. If wanted, it can be made from the Tables in similar manner to hours and minutes, or the latter can be converted into the former by Table XXV.*]

Example 2.—*The reverse process.* This is not really wanted, but it shows that the Tables are accurate.

Rule. Take the *Sū. Siddh.* time from Table I., cols. 13, 14, 15A, 17A, and convert to *Ār. Siddh.* time by Table XVII. with signs reversed.

Wanted the *Ār. Siddh.* M.S. in K.Y. 4491 expired, A.D. 1390.

	d.	*w.*	*h.*	*m.*
By Table I., cols. as stated	26 March (85)	0	15	43
By Table XVII., sign reversed			— 1	38
Answer. M.S. by *Ār. Siddh.*	= 26 March (Sat.), at		14	5

(as given in col. 17 of Table I.)

Example 3.—*To find the time of true sidereal Mēsha saṁkrānti according to the Ārya Siddhānta in a year earlier than K.Y.* 3401 *expired, A.D.* 300–1, *and therefore not to be found from Table I. of the "Indian Calendar."* (For explanation of process see above under "Correction I., Note," § 47.)

Rule. Find the Mēsha saṁkrānti time by Table I. according to the *Ārya Siddhānta* for any year removed by an interval of 576 years, or any multiple of 576 years, from the given year; and deduct from the day and month of the Mēsha saṁkrānti as there found 5 days for every such period of 576 years. Retain the ghaṭikās and palas, or hours and minutes as found. For the week-day, subtract from the found week-day 4 week-days for every such period.

Wanted according to the *Ārya Siddhānta* the moment of Mēsha saṁkrānti in 500 B.C. (K.Y. 2602 expired), and the day of the week.

[1] M.S. in these examples means Mēsha saṁkrānti.

There having been no year 0 between 1 B.C. and A.D. 1, we have to add one year to the interval from 500 B.C. to the selected year. We take two 576-year intervals. 576 × 2 + 1 = 1153 years. 1153 — 500 = A.D. 653. The *Ārya Siddhānta* Mēsha saṁkrānti in A.D. 653 took place (*Table I.*) on March 19th, Tuesday, at 22 h. 32 m. For two periods of 576 years each, deduct 10 days from the day of the month and 8 week-days from the week-day. Therefore the M.S., by the *Ār. Siddh.*, in 500 B.C. took place on Monday, March 9th, at 22 h. 32 m. [And the M.S. in A.D. 77, which was removed from 500 B.C. and from A.D. 1153, by one period of 576 years took place on March 14th, Friday, at 22 h. 32 m.]

EXAMPLE 4.—*To find the time of true sidereal Mēsha saṁkrānti by the Sūrya Siddhānta in a similar year.*

Rule. Find the moment of true Mēsha saṁkrānti by the *Ārya Siddhānta* as directed in Example 3, and convert it to the same according to the *Sūrya Siddhānta* by use of the Table on p. 55 of the *Indian Calendar.* The two authorities were together in A.D. 496. The Table gives the difference between them for years earlier or later, measured by the number of years intervening between A.D. 496 and the given year.[1] (§§ 47, 56.)

Wanted the moment of Mēsha saṁkrānti according to the *Sūrya Siddhānta* in 500 B.C. (K.Y. 2602 expired), and the day of the week.

We found in the last example that the Mēsha saṁkrānti in 500 B.C. according to the *Ārya Siddhānta* occurred on Monday, March 9th, at 22 h. 32 m. The interval between 500 B.C. and A.D. 496, there being no year A.D. 0, is 995 years. And from the Table on p. 55, *Ind. Cal.*, we have, for 900 years, 90 years and 5 years respectively, 1 h. 38.4 m., 9.8 m. and 0.5 m. Total, 1 h. 48.7 m., or, roughly, 1 h. 49 m. Deducting this from the *Ārya-Siddhānta*-time, we have, for the moment of Mēsha saṁkrānti in 500 B.C. by the *Sūrya Siddhānta*, March 9th, Monday, at 20 h. 43 m. Laṅkā time.

EXAMPLE 5.—*To find the time of mean sidereal Mēsha saṁkrānti according to the Ārya Siddhānta for any year.* [See § 26, pp. 11, 12 of the *Ind. Cal.*, and §§ 57–62 above.]

Rule. Find the time of true sidereal Mēsha saṁkrānti according to the *Ārya Siddhānta* from Table I., cols. 13 to 17, or by Example 3 above. Add to this the śōdhya difference according to that authority, viz., 2 d. 8 gh. 51 p. 15 v., or 2 d. 3 h. 32 m. 30 s. This gives the time of mean Mēsha saṁkrānti.

(*a*) Wanted the time of mean Mēsha saṁkrānti of K.Y. 4041 expired, A.D. 940.

	d.	*w.*	*h.*	*m.*
Table I. (*cols.* 13 to 17). True M.S.	22 March	1 (Sun.)	4	20
+ śōdhya by Ā.S.	2	2	3	32½
Answer. Mean M.S. took place on	24 March	3 (Tues.) at	7	52½

(*b*) Wanted the time of mean Mēsha saṁkrānti of K.Y. 0 expired, or 1 current = the epoch of Hindū astronomy. Work by Example 3. Six cycles of 576 years = 3456 years. The corresponding year of Table I. is K.Y. 3456 expired, or 3457 current. For the day of the month we deduct (6 × 5) 30 days, and for the day of the week (6 × 4) 24 days, retaining the hours and minutes given.

	d.		*w.*	*h.*	*m.*
True M.S. K.Y. 3456 expired (*Table I.*)	17 March	(76)	6	20	27
		— (30)	— 24		
True M.S. K.Y. 0 expired, 1 current	15 Feb.	(46)	3	20	27
Add śōdhya	2	2	2	3	32½
	17 Feb.	(48)	5	23	59½

[1] Table XVII. is based on these figures of difference, but it only concerns the 1600 years of Table I. The Table on p. 55 enables the difference to be found for any number of years intervening between the given year and the base year.

This is practically — 23 h. 59½ m. being taken as 24 h.—February 18th, Friday, 0 h. Laṅkā time, or 6 a.m., which is the time of the epoch according to the *Ārya Siddhānta* (*cf.*, *Jacobi, Ind. Ant., XVII.*, 159*a*). The difference is only 30 seconds, due to omission of that amount in the time fixed for K.Y. 3456 in Table I. (*See " Hint " No.* 20, *above.*) The time of true Mēsha saṁkrānti in K.Y. 1 current was really 20 h. 27 m. 30 s., not 20 h. 27 m.; and if we add the 30 seconds the result is precisely February 18th, 0 h, Laṅkā time. [Another way is to use Table XXXVIII.C., and apply the rule in § 54.]

EXAMPLE 6.—*The same according to the Sūrya Siddhānta.*

Rule. Find the time of true Mēsha saṁkrānti according to the *Sūrya Siddhānta* from Table I., cols. 13, 14, 15A, 17A., or as in Example 4 above. Add to this the śōdhya difference according to that authority, viz., 2 d. 10 gh. 14 p. 30 v., or 2 d. 4 h. 5 m. 48 s. This gives the time of mean Mēsha saṁkrānti.

(*a*) Wanted the time of mean Mēsha saṁkrānti of K.Y. 4269 expired, A.D. 1168 :—

	d.	*w.*	*h.*	*m.*
(*Table I., cols.* 13, 14, 17*a*). True M.S.	24 March	1	5	3
+ śōdhya by *Sūr. Siddh.*	2	2	4	6
Mean M.S. by *Sūr. Siddh.*	26 March	3	9	9

Answer. 9 h. 9 m. Laṅkā time on Tuesday, March 26th.

(*b*) Wanted the time of mean Mēsha saṁkrānti of K.Y. 4041 expired, A.D. 940 :—

	d.	*w.*	*h.*	*m.*
(*Table I., cols.* 13–17). True M.S. by *Ār. Siddh.* .	22 March	1	4	20
Convert to *Sūr. Siddh.* by Table XVII. . . .				+ 49
True M.S. by *Sūr. Siddh.*	22 March	1	5	9
Add *Sūr. Siddh.* śōdhya	2	2	4	6
Mean M.S. by *Sūr. Siddh.*	24 March	3	9	15

Answer. 9 h. 15 m. Laṅkā time on Tuesday, March 24th.

(*c*) Wanted the time of mean Mēsha saṁkrānti of K.Y. 1 current, or the epoch of Hindū astronomy, according to the *Sūrya Siddhānta.*

	d.	*w.*	*h.*	*m.*	*s.*
(Compare Examples 3, 4, 5.) In Example 5 (*b*) we found the time of true Mēsha saṁkrānti in K.Y. 1 current, by the *Ārya Siddhānta*, to be exactly. .	15 Feb.	3	20	27	30
Convert to the *Sūrya Siddhānta* by Table on p. 55 of the *Ind. Cal.*, with an interval of 3598 years (A.D. 496 = K.Y. 3598 current)			— 6	— 33	— 18
True M.S. K.Y. 1 current by *Sū. Siddh.*	15 Feb.	3	13	54	12
Add *Sūr. Siddh.* śōdhya	+ 2	2	4	5	48
Mean M.S. K.Y. 1 current	17 Feb.	5	18	0	0

Answer. 18 h. Laṅkā time on February 17th, Thursday, 3102 B.C.

EXAMPLE 7.—*To convert the time of a mean Mēsha saṁkrānti found according to the Ārya Siddhānta into the same according to the Sūrya Siddhānta.*

Rule. Apply Corrections I. (§§ 46–54) and III. (§§ 57–59) by Table XVII., or the Table on p. 55 of the *Indian Calendar*, and by the śōdhya time-difference between the two authorities (+ 33 m. 18 s.).

For K.Y. 4041 expired, A.D. 940 (*Example* 5*a*), we are given the time by the *Ārya Siddhānta* as on Tuesday, March 24th, at 7 h. 52 m. 30 s. By Table XVII., Correction I. is + 49 m.; the śōdhya difference

is + 33 m. 18 s. Total, 1 h. 22 m. 18 s. Adding this to 7 h. 52 m. 30 s., we have 9 h. 14 m. 48 s.; or 9 h. 15 m. on the same day (as we have already found to be the time of mean M.S. by the *Sūrya Siddhānta* in Example 6 (*b*)).

EXAMPLE 8.—*The reverse process.*

Rule. Apply the corrections as in the last example, but with reversed signs.

This is merely the converse of the last, and requires no working.

EXAMPLE 9.—*To find, according to the Ārya Siddhānta, the time of tropical Mēsha saṁkrānti in any year.*

Rule. This is given on pp. 152-3 of the *Indian Calendar*, and the process is explained above (*Tropical samkrāntis*, § 33, *&c.*).

Wanted the time of occurrence according to the *Ārya Siddhānta* of the tropical (sāyana) Mēsha saṁkrānti of Śaka 1000 current, K.Y. 4179 current, A.D. 1077-78.

I take the year for which the process was shown in the *Indian Calendar* because its accuracy within one minute has been fully established. According to the *Ārya Siddhānta* the base-year is Śaka 445. We find the time of tropical Mēsha saṁkrānti in the same way as all other tropical saṁkrāntis, and, for this, Table I. gives us our starting point. The time of true sidereal Mēsha saṁkrānti in the given year was March 23rd at 14 h. 52 m.

(*a*) *Rough calculation.* (The given year, Śaka) 1000 — 445 (the base-year) = 555, and 555 ghaṭikās = 9 d. 15 gh., or (*Table XXV.*) 9 d. 6 h. Deducting 9 d. 6 h. from March 23rd., 14 h. 52 m., we have March 14th 8 h. 52 m., and this was roughly the time of tropical Mēsha saṁkrānti in the given year.

(*b*, i.) *Accurate calculation.* We note that since the tropical was earlier than the sidereal Mēsha saṁkrānti by about 9 days, those days belonged to sidereal (nirayaṇa) Mīna,[1] and that the length of Mīna (*Table XVIII.A, col.* 7) is 30 d. 8 h. 7 m. 42 s. The difference of years gives us (as above) 555 gh., or, multiplied by $\frac{1}{60}=9\frac{15}{60}$, or 9° 15′ in ayanāṁśas (degrees of precession), or $9\frac{1}{4}$°.

$$\frac{30\text{ d. } 8\text{ h. } 7\text{ m. } 42\text{ s.} \times 9\frac{1}{4}}{30} = 9\text{ d. } 8\text{ h. } 30\text{ m. } 22\text{ s.}$$

We ignore seconds less than half a minute.

			h.	*m.*
True sidereal Mēsha saṁkrānti	March	23	14	52
	—	9	8	30
Tropical M.S.	March	14	6	22

Answer. Tropical Mēsha saṁkrānti of Ś. 1000 occurred, according to the *Ārya Siddhānta*, on March 14th at 6 h. 22 m. after sunrise.

(*b*, ii.) In Table XX.A I have attempted to simplify the above process. The figures in col. 2 of that Table give, for each sidereal month, the length of the month divided by 30, or the time occupied by the sun in travelling 1°; so that instead of the element of calculation (for Mīna)—

$$\frac{30\text{ d. } 8\text{ h. } 7\text{ m. } 42\text{ s.} \times 9\frac{1}{4}}{30}$$

we may substitute (*Table XX.A, col.* 2, *for Mīna*) 1 d. 0 h. 16 m. 15. 4s.×$9\frac{1}{4}$, which=9 d. 8 h. 30 m. 22 s., *i.e.*, gives the same result as in *b* (i.).

(*b*, iii.) Or, again, those who prefer it may still further simplify the sum by taking the equivalent in decimals of $\frac{1}{30}$th of the month Mīna, viz., 1.0113 d. (if only four places of decimals are used), as given in the same Table, and multiplying it by $9\frac{1}{4}$, or 9.25. This results in 9.354525, which, taken as days, = 9 d. 8 h. 30 m. 31 s. (*Table XXXVI.*) Such is the result working with only four places of decimals.

[1] See note following Example 18B.

If we take the full figures as given, viz., 1.01128935̇18̇, this, multiplied by 9.25, gives exactly 9 d. 8 h. 30 m. 22 s.

EXAMPLE 10.—*To find, according to the Sūrya Siddhānta, the time of tropical Mēsha saṁkrānti in any year.*

Rule. (*See pp.* 152–3, *Ind. Cal., and above "Tropical saṁkrāntis,"* § 33, *&c.*)

Wanted the time of occurrence according to the *Sūrya Siddhānta* of tropical (sāyana) Mēsha saṁkrānti of Śaka 1000 current, K.Y. 4179 current, A.D. 1077–78, the same year as in the last example.

The remarks at the beginning of Example 9 apply equally to this problem. We start with true nirayaṇa (or sidereal) Mēsha saṁkrānti-time, as given according to the *Ārya Siddhānta* for the year in question, in Table I., viz., March 23rd, 14 h. 52 m. We next convert this to the time according to the *Sūrya Siddhānta* by Table XVII., adding 64 m. This gives us the same moment by the *Sūrya Siddhānta* as March 23rd, 15 h. 56 m.

(*a*) *Rough calculation.* (The given year Śaka) 1000 — 422 (the base-year, both current) = 578, and 578 ghaṭikās = 9 d. 38 gh. = (*Table XXV.*) 9 d. 15 h. 12 m. Deducting this period from March 23rd 15 h. 56 m., we have March 14th 0 h. 44 m., and this was roughly the time of tropical Mēsha saṁkrānti in the given year.

(*b*, i.) *Accurate calculation.* Noting that the intervening days belonged to the sidereal month Mīna,[1] and that the length of Mīna was, according to the *Sūrya Siddhānta* (*Table XVIII.B*), 30 d. 8 h. 29 m. 1 s., while $578 \times \frac{3}{200} = 8.67$ = (in ayanāṁśas) 8° 40′ 12″, we multiply $\frac{1}{30}$th of the length of Mīna by the ayanāṁśas.

$$\frac{30\text{ d. }8\text{ h. }29\text{ m. }1\text{ s.} \times 8° 40' 12''}{30} = 8\text{ d. }18\text{ h. }31\text{ m. }52\text{ s.}$$

			h.	m.
Sidereal Mēsha saṁkrānti	March	23	15	56
Less		8	18	32
Tropical Mēsha saṁkrānti	March	14	21	24

This was the required day and time.

(*b*, ii.) If, as in the last example (*b*, ii.) we use Table XX.A the sum to be done is—

$$1\text{ d. }0\text{ h. }16\text{ m. }58\text{ s.} \times 8° 40' 12''$$

which comes to the same result.

(*b*, iii.) And if, as in the last example (*b*, iii.) we use the decimals for each element of the sum, and this is by far the easiest and shortest method, we have—

$$1.01178 \times 8.67$$

which = 8.7721326, and this, by Table XXXVI., = 8 d. 18 h. 31 m. 52 s., and gives us the same result.

Note. [Comparing the results of Examples 9 and 10, it will be noticed that whereas the difference in the case of the former (according to the *Ārya Siddhānta*) between the rough and the accurate results, viz., 8 h. 52 m. and 6 h. 22 m. is only 2 h. 30 m.; in the second case (by the *Sūrya Siddhānta*) the difference between the rough and the accurate results amounts to as much as 20 h. 40 m. When working by the *Sūrya Siddhānta* one must always expect considerable divergence in this respect, increasing with the distance of the given year from the base year; because the first rough calculation is made on the basis of the degrees of precession, or ayanāṁśas, amounting to 1′ per annum, which is taken as = 1 ghaṭikā per annum in time, while the second, accurate, calculation is based on the actual amount of precession according to that authority, viz., 54″ per annum, which = 0.9 gh. per annum in time. In 578 years this difference is considerable.]

[1] See note following Example 18B.

Other saṁkrāntis: true, mean, and tropical.

EXAMPLE 11.—*To find the moment of any true sidereal saṁkrānti by the Ārya Siddhānta.*

Each saṁkrānti marks the astronomical beginning of the solar month which takes its name, being the moment when the sun in his course, measured by his apparent longitude, enters a sign.

Rule. Find the moment of true Mēsha saṁkrānti by the *Ārya Siddhānta* for the given year from Table I., or, for years earlier than A.D. 300, by Example 3. Add to it the collective duration given in cols. 3 or 4 of Table XVIII.A from that moment to the given saṁkrānti. (§ 59.)

Wanted the time of Vṛiśchika saṁkrānti according to the *Ārya Siddhānta* in K.Y. 4321 expired, A.D. 1220—21

	d.	*w.*	*h.*	*m.*
(*Table I.*) M.S. for the year	24 March (84)	3	14	40
(*Table XVIII.A*) Coll. Dur. to Vṛiś. saṁk. . .	(216)	6	19	6
Vṛiśchika saṁkrānti	(301)	3	9	46

301 = (*Table IX.*), A.D. 1220 being a Leap-year, Oct. 27th. 3 = Tuesday.

Answer. Tuesday, October 27th, A.D. 1220, at 9 h. 46 m. Laṅkā time, *i.e.*, measured from mean sunrise.

EXAMPLE 12.—*The same by the Sūrya Siddhānta.*

Rule. Find the time of true Mēsha saṁkrānti according to the *Sūrya Siddhānta* from Table I., or by Examples 1 or 4. Add the collective duration to the given saṁkrānti as given in cols. 3 or 4 of Table XVIII.B.

Wanted the time of Vṛiśchika saṁkrānti by the *Sūrya Siddhānta* in K.Y. 4321 expired, A.D. 1220-21.

	d.	*w.*	*h.*	*m.*
(*Table I.*) M.S. for the year	24 March (84)	3	15	59
(*Table XVIII.B*) Coll. Dur. to Vṛiś. saṁk. . .	(216)	6	19	54
Vṛiś. saṁk.	(301)	3	11	53

Answer. Tuesday, October 27th, A.D. 1220, at 11 h. 53 m. Laṅkā time. (*Compare with Example* 11.)

EXAMPLE 13.—*To convert the time of any true saṁkrānti as found by the Ārya Siddhānta into the same according to the Sūrya Siddhānta.*

Table XVIII.C has been framed to enable this to be done.

Rule. The time by the *Ārya Siddhānta* being given, apply to it Corrections I. (*Table XVII.*) and II. (*Table XVIII.C*), both Tables as they stand. (§§ 46, 56.)

E.g., Wanted the time of true Vṛiśchika saṁkrānti by the *Sūrya Siddhānta* in the same year as in Examples 11, 12, its time according to the *Ārya Siddhānta* being October 27th, A.D. 1220, at 9 h. 46 m.

		h.	*m.*
Correction I. (*Table XVII.*)	+	1	19
Correction II. (*Table XVIII.C*)	+		48
		2	7

9 h. 46 m. + 2 h. 7 m. = 11 h. 53 m.; and this was the exact time as found in Example 12.

EXAMPLE 14.—*To convert the time of any true saṁkrānti as found by the Sūrya Siddhānta into the same according to the Ārya Siddhānta.* This is the reverse of Example 13.

Rule. The time by the *Sūrya Siddhānta* being given, apply to it Correction I. and Correction II. with signs ıeversed. (§§ 46, 56.)

E.g., Take the same month and year as in Example 13. Given October 27th, A.D. 1220, at 11 h. 53 m. as the time by the *Sūrya Siddhānta*, the two corrections to be applied are — 1 h. 19 m. and — 48 m., which converts 11 h. 53 m. into 9 h. 46 m.

EXAMPLE 15.—*To find the moment of any mean sidereal saṁkrānti according to the Ārya Siddhānta.*

Rule. Find the moment of true Mēsha saṁkrānti from Table I., or by Example 3 above. Add the śōdhya interval according to the *Ārya Siddhānta* (*Example* 5). Add to the product the interval from Mēsha saṁkrānti to the given saṁkrānti, using Table XIX.A. (§§ 57, 59.)

Wanted the time of mean Tulā saṁkrānti by the *Ārya Siddhānta* in Śaka 1153 expired, A.D. 1231–32.

	d.	*w.*	*h.*	*m.*
True M.S. by *Ār. Sid.* (*Table I.*)	25 March (84)	3	10	57
Add śōdhya (*Example* 5)	(2)	2	3	32½
Mean M.S. by *Ār. Sid.*	27 March (86)	5	14	29½
Coll. Dur. to Tulā saṁk. (*Table XIX.A*)	(182)	0	15	6¼
Mean Tulā saṁk. by *Ār. Sid.*	(269)	6	5	36

Answer. 269 = (*Table IX.*), September 26th. 6 = Friday. Friday, September 26th, A.D. 1231, at 5 h. 36 m. Laṅkā time.

EXAMPLE 16.—*The same, according to the Sūrya Siddhānta.*

Rule. Find the moment of true Mēsha saṁkrānti according to the *Sūrya Siddhānta* from Table I., or by Examples 1 or 4. Add the śōdhya interval according to the same Siddhānta (*Example* 6). Add to the product the collective duration from Mēsha saṁkrānti to the given saṁkrānti, using Table XIX.B.

Wanted the time of mean Tulā saṁkrānti by the *Sūrya Siddhānta* in Śaka 1153 expired, A.D. 1231–32.

	d.	*w.*	*h.*	*m.*
True M.S. by *Sū. Sid.* (*Table I.*)	25 March (84)	3	12	18
Add śōdhya (*Example* 6).	(2)	2	4	6
Mean M.S. by *Sū. Sid.*	27 March (86)	5	16	24
Coll. Dur. to Tulā saṁk. (*Table XIX.B*)	(182)	0	15	6
Mean Tulā saṁk. by *Sū. Sid.*	(269)	6	7	30

Answer. Friday, September 26th (= 269 by Table IX.), A.D. 1231, at 7 h. 30 m. Laṅkā time.

EXAMPLE 17.—*To convert the time of any mean sidereal saṁkrānti as found according to the Ārya Siddhānta into the same according to the Sūrya Siddhānta.*

Rule. The time according to the *Ārya Siddhānta* being given, apply to it Correction I. (*Table XVII.* as it stands) and the time-difference between the śōdhya intervals according to the two authorities, viz. + 33 m. 18 s. (*See* "Correction III." § 57, *above.*)[1]

Wanted the time of mean Tulā saṁkrānti by the *Sūrya Siddhānta* in Śaka 1153 expired, A.D. 1231–32, the time of the same according to the *Ārya Siddhānta* being given as Friday, September 26th, A.D. 1231, at 5 h. 36 m.

		h.	*m.*
Ār. Sid. hours and minutes		5	36
Corr. I. (Table XVII.)	+	1	21
Śōdhya difference	+		33
		7	30

Answer. Friday, September 26th, A.D. 1231, at 7 h. 30 m. Laṅkā time (as found in Example 16).

[1] Note that while for the similar conversion of true sidereal saṁkrāntis we have to take into account the different lengths of true months by the two authorities, the difference in the lengths of mean months is so slight that it may as a rule be safely ignored.

EXAMPLE 18.—*The reverse process.*

Rule. The time according to the *Sūrya Siddhānta* being given, apply to it Correction I. (Table XVII., with signs reversed) and the time-difference between the śōdhya intervals according to the two authorities, viz. — 33 m. 18 s.

Wanted the time of mean Tulā saṁkrānti by the *Ārya Siddhānta* in Śaka 1153 expired, A.D. 1231–32, the time of the same according to the *Sūrya Siddhānta* being given as Friday, September 26th, A.D. 1231, at 7 h. 30 m.

		h.	*m.*
Sū. Sid. hours and minutes		7	30
Corr. I. (Table XVII.)	—	1	21
Śōdhya difference	—		33
		5	36

Answer. Friday, September 26th, A.D. 1231, at 5 h. 36 m. Laṅkā time.

EXAMPLE 18A.—*To find the moment of any true tropical saṁkrānti according to the Ārya Siddhānta.*

Rule. (This is fully given above, under "Tropical saṁkrāntis," §§ 36 to 39. See also pp. 152–3 of the *Indian Calendar*, and the working for tropical Mēsha saṁkrānti shown in Example 9.) Find the moment of the corresponding true sidereal saṁkrānti as in Example 11.

Wanted the time of tropical Makara saṁkrānti in the year Śaka 1000 current, A.D. 1077–78 :—

	d.	*w.*	*h.*	*m.*
Time of sidereal Mēsha saṁk. (*Table I.*)	23 March (82)	5	14	52
Coll. Dur. to Makara saṁk. (*Table XVIII.A*)	(275)	2	15	43
Time of sidereal Makara saṁk.	(358)	1	6	35

The Makara saṁkrānti therefore occurred on Sunday, December 24th (358, *Table IX.*), at 6 h. 35 m. Laṅkā time.

(*a*) *Rough calculation.* (The given year, Śaka) 1000 — 445 (the base year) = 555. 555 ghaṭikās = 9 days 15 gh. = 9 d. 6 h. Deducting 9 d. 6 h. from December 24th, 6 h. 35 m., we arrive at Friday, December 15th, at 0 h. 35 m. Laṅkā time, or 35 m. after sunrise, as the required moment of tropical Makara saṁkrānti in the given year.

(*b*, i.) *Accurate calculation.* The 9 days in question belong to the sidereal month Dhanus, the length of which is, by the *Ārya Siddhānta* (*Table on p.* 10, *Ind. Cal., or Table XVIII.A*), 29 d. 8 h. 24 m. 48 s. The difference of years, 555, multiplied by $\frac{1}{60} = 9\frac{15}{60}$, or, in ayanāṁśas (degrees of precession), 9° 15′.

$$\frac{29 \text{ d. } 8 \text{ h. } 24 \text{ m. } 48 \text{ s.} \times 9° \ 15'}{30} = 9 \text{ d. } 1 \text{ h. } 11 \text{ m. } 39 \text{ s.}$$

Call this 9 d. 1 h. 12 m., and deduct it from the time of the true sidereal Makara saṁkrānti already found.

d.		*w.*	*h.*	*m.*
24 Dec.	(358)	1	6	35
9	(9)	2	1	12
15 Dec.	349	6	5	23

Answer. Friday, December 15th, A.D. 1077, at 5 h. 23 m. Laṅkā time.

(*b*, ii.) The sum above being troublesome, we may substitute the hours, &c., for one degree of Dhanus, and carry out the calculation by col. 2 of Table XX.A. The sum is then simplified into—

$$0 \text{ d. } 23 \text{ h. } 28 \text{ m. } 49.6 \text{ s.} \times 9° \ 15'$$

which yields the same result.

(*b*, iii.) Or we may make the calculation still easier by working entirely in decimals by the same Table, 9° 15′ being 9.25°.

$$0.97835 \times 9.25 = 9.0497375.$$

This, taken in days, &c., by Table XXXVI. = 9 d. 1 h. 11 m. 37.54 s., which differs from the first (*b*, i.) by about one second only. Using the full number of decimals the results agree exactly.

Example 18B.—*To find the moment of any true tropical saṁkrānti according to the Sūrya Siddhānta.*

Rule. (*See Rule in Example* 18A.) First find the moment of the true sidereal saṁkrānti in the given year, and then work according to rule.

Wanted the time of tropical Makara saṁkrānti, according to the *Sūrya Siddhānta*, of Śaka 1000 current, A.D. 1077–78.

	d.	*w.*	*h.*	*m.*
True. sidereal Mēsha saṁk. by *Ār. Siddh.* (*Table I.*) .	23 March (82)	5	14	52
Corr. I. (*Table XVII.*) (*See Example* 1) . . . +			1	3
True sidereal M.S. by *Sūrya Siddh.*	23 March (82)	5	15	55
Collective duration to Makara saṁkrānti by the *Sūrya Siddh.* (*Table XVIII.B*)	(275)	2	15	17
	(358)	1	7	12

358 = December 24th. 1 = Sunday. True sidereal Makara saṁkrānti took place on Sunday, December 24th, A.D. 1077, at 7 h. 12 m. Laṅkā time.

(*a*) *Rough calculation.* (The given year, Śaka.) 1000 — 422 (the base-year according to this Siddhānta) = 578. 578 ghaṭikās = 9 days 38 ghaṭikās = (*Table XXV.*) 9 d. 15 h. 12 m.

		h.	*m.*
Sidereal Makara saṁkrānti	Dec. 24	7	12
Deduct	9	15	12
	Dec. 14	16	0

Roughly, tropical Makara saṁkrānti occurred on December 14th, A.D. 1077, at 16 h. 0 m. Laṅkā time.

(*b*, i.) *Accurate calculation.* The 9 days in question belong to the sidereal month Dhanus, the length of which according to the *Sūrya Siddhānta* is (*Table on p.* 10, *Ind. Cal., or Table XVIII.B*) 29 d. 7 h. 37 m. 36 s. The difference of years, $578 \times \frac{3}{200} = 8.67 =$, in ayanāṁśas, 8° 40′ 12″.

$$\frac{29\text{ d. }7\text{ h. }37\text{ m. }36\text{ s.} \times 8^\circ\ 40'\ 12''}{30} = 8\text{ d. }11\text{ h. }50\text{ m. }15\text{ s.}$$

Call this 8 d. 11 h. 50 m., and deduct it from the time of true sidereal Makara saṁkrānti already found

	h.	*m.*
Dec. 24	7	12
— 8	11	50
Dec. 15	19	22

Answer. The tropical (sāyana) Makara saṁkrānti took place on December 15th, A.D. 1077, at 19 h. 22 m. Laṅkā time.

(*b*, ii.) Instead of the above fraction $\frac{29\text{ d. }7\text{ h. }37\text{ m. }36\text{ s.}}{30}$ we may use Table XX.A, where this division has been carried out, and substitute for it 0 d. 23 h. 27 m. 15.2 s., multiplying this by 8° 40′ 12″. The result is the same.

(*b*, iii.) Or, lastly, we may, saving much trouble, work entirely by decimals as given in Table XX.A. Here the sum to be done is—

$$0.977259 \times 8.67. \quad \text{This} = 8.492838,$$

and =, as before, 8 d. 11 h. 50 m. 15 s.

Note to Examples 9, 10, 18A, 18B.

[It must be remembered that, whereas in years later than the base-year of the Siddhānta the days intervening between the tropical and sidereal saṁkrāntis belong to the sidereal month *preceding* the sidereal saṁkrānti, in years earlier than the base-year those days belong to the month bearing the same name as, or to a month *later* than, the sidereal saṁkrānti. The base-year, for instance, of the *Ārya Siddhānta* for tropical calculations is Śaka 445 current, A.D. 522–23, when by that authority the sidereal and tropical signs coincided. After that year the tropical saṁkrāntis preceded the sidereal, or were earlier in time than they, and the intervening period belonged to the sidereal months preceding the given one. On the other hand, in years earlier than Śaka 445 current the tropical saṁkrāntis were later in time than the sidereal one, and the intervening days fell in the same, or, in case of much earlier years, a later sidereal month. It is not possible to simplify by tabulation the process of work for tropical saṁkrāntis, for we cannot, as in the case of sidereal saṁkrāntis, ascertain and tabulate the exact lengths of the months. These vary in every year in consequence of the change of position of the equinoctial point. Calculation for the moment of occurrence of every tropical saṁkrānti must therefore be specially made according to the rules given.]

Civil days.

EXAMPLE 19.—*To find the European civil day corresponding to a given Hindū solar day by either Siddhānta.*

Rule. Find, from Table I. or by Examples 1, 3, or 4, the moment of true sidereal Mēsha saṁkrānti according to the authority used. Add to the time so found the collective duration of intervening solar months, by the same authority, to the end of the month preceding the given month (*Table III. of the Indian Calendar, or Tables XVIII.A or XVIII.B*). This gives the moment of saṁkrānti at the beginning of the given month. Decide by the rules given under "*Days of a civil month,*" § 43, above, and from the moment of the saṁkrānti last found, which European day was the first civil day of the solar month. Add the number of intervening days, remembering that the Hindū civil day begins at sunrise.

Wanted the European day corresponding to Tuesday, the 24th day of Karka in K.Y. 4372 expired.

This is an actual date of an inscription. The year = A.D. 1271–72. Work by the *Ārya Siddhānta* first :—

	d.	*w.*	*h.*	*m.*
Mēsha saṁkrānti (*Table I.*)	25 March (84)	4	19	17
Coll. dur. to Karka saṁk. (*Table XVIII.A*) . .	(93)	2	22	24
Karka saṁkrānti	27 June (178)	0	17	41

We examine the rules for the first civil day of Karka :—

(i.) Bengal Rule. It began on Sunday, June 28th.

(ii.) Orissa Rule. It began on Saturday, June 27th.

(iii.) Tamil Rule. It began on Sunday, June 28th.

(iv.) Malabar Rule. It began on Sunday, June 28th.

Add 23 days in each case, the given day being the 24th, and we have for result (Rules i., iii., iv.) Tuesday, July 21st, or (Rule ii.) Monday, July 20th. The inscription itself quotes Tuesday as the

week-day, and, since it was in a South-Indian inscription, we gather that the date was fixed by one of the South-Indian Rules iii. or iv. (*See footnote 3, p. 12, Indian Calendar.*)

[Work by the *Sūrya Siddhānta* is precisely similar, only the Mēsha saṁkrānti must be fixed by that authority, and the collective duration of the months must be taken from Table XVIII.B.]

Luni-Solar reckoning.

True lunar months and tithis.

Example 20.—*To find the true current tithi, its beginning-time and ending-time at any moment by the Ārya or Sūrya Siddhānta.*

Rule. (*For full directions see Examples I. to VIII.*, §§ 139–148, *Indian Calendar, pp.* 77–86.) Having established the exact year concerned, take from Table I. the details (*cols.* 19–25) for mean sunrise on the first civil day of the luni-solar year. Add to these the similar details for the number of civil days contained in the interval between that moment and mean sunrise on the given day, obtaining them from cols. 3, 3A of Table III. and from Table IV. The product shows the details for mean sunrise on the day concerned. If necessary, add the same details for any intervening hours and minutes up to the special moment given. From the *a, b, c* so resulting calculate the *t* according to the *Indian Calendar* rule quoted, continuing the process as there laid down, if absolute accuracy is desired—the first result obtained being a close approximation. The final result is absolutely accurate in mean time. If it is necessary to work for true or apparent time use the corrections given in Tables F and G of "*Eclipses of the Moon in India*," or those given by Prof. Jacobi in *Epigraphia Indica*, II., 487 *ff*. The process is the same both by the *Ārya* and *Sūrya Siddhāntas.*

Wanted the tithi current at mean sunrise on March 25th, A.D. 1149, K.Y. 4250 expired.

Table I., col. 19, shows that the first civil day of the luni-solar year, or the first day of the month Chaitra in this year, was March 12th. We take the necessary details :—

	d.	*w.*	*a.*	*b.*	*c.*
At mean sunrise, Chaitra śukla 1. . . .	12 March (71)	0	82	951	246
Interval to given day, 13 days (*Table IV.*). For the week-day (13 — 7 =) 6 . . .	+ 13 (13)	6	4402	472	36
At mean sunrise, March 25th (6=Friday)	25 March (84)	6	4484	423	282
Equation *b* (*Table VI.*)			206		
Equation *c* (*Table VII.*)			1		
		t =	4691		

4691, by Table VIII., col. 3,= the 15th śukla tithi of Chaitra, and this was the true tithi current at mean sunrise. This is the date of an actual inscription in South India. If the moment given had been a stated hour and minute of that day we should have added to the *a, b, c* already obtained the *a, b, c* for those hours and minutes from Table V., and from the total have obtained the value of *t*.

[The inscription in question gave the date as in a king's regnal year known to correspond with K.Y. 4250 expired, and it told us that at mean sunrise of a certain Friday the 15th tithi of the bright half (śukla) of the luni-solar month Chaitra was current. The luni-solar year K.Y. current 4251 began, as already shown, on March 12th, A.D. 1149. The number of elapsed *tithis* was 14. But if we had begun by adding to the *a, b, c* of March 12th the *a, b, c* for 14 *days*, we should have found that the 16th tithi, and not the 15th, was current at sunrise, and that the corresponding week-day was a Saturday. This shows that it is unsafe to work otherwise than by the rule given.]

The beginning of the 15th tithi. At mean sunrise on March 25th the tithi-index (*t*) was found to be 4691. The beginning of the tithi was (*Table VIII., 15th śukla tithi, col.* 3) 4667, and the ending 5000. 4691 — 4667 = 24 = (*Table X.*) 1 h. 42 m. in mean time. The 15th śukla tithi, therefore, began approximately 1 h. 42 m. before mean sunrise on March 25th. But let us suppose that we want perfect accuracy. We calculate for the value of *t* at 1 h. 42 m. before sunrise by deducting from the *a, b, c* for sunrise the *a, b, c* for that period by Table V.

	a.	*b.*	*c.*
Values (found) for sunrise	4484	423	282
Values for 1 hour (*Table V.*)	— 14	2	0
Values for 42 minutes (*Table V.*)	— 10	1	0
	4460	420	282
Equation *b* (*Table VI.*)	208		
Equation *c* (*Table VII.*)	1		
	4669		

4669 — 4667 (the beginning-point of the 15th śuk. tithi) = 2 = (*Table X.*) 9 m., by which amount earlier than 1 h. 42 m. the tithi really began. This gives us 1 h. 51 m. before sunrise, in mean time, as the exact beginning time of the tithi.

The ending of the 15th śukla tithi. 5000 — 4691 = 309 = (*Table X.*) 21 h. 16 m. + 38 m. = 21 h. 54 m. The tithi expired approximately at 21 h. 54 m. after mean sunrise on March 25th. For exact calculation we work as before :—

	a.	*b.*	*c.*
Values (found) for sunrise	4484	423	282
Values for 21 h. (*Table V.*)	+ 296	32	2
Values for 54 m. (*Table V.*)	+ 13	1	0
	4793	456	284
Equation *b* (*Table VI.*)	179		
Equation *c* (*Table VII.*)	1		
t =	4973		

5000 — 4973 = 27 = (*Table X.*) 1 h. 55 m. We have to arrive at exactly 5000, and have discovered that the time, 21 h. 54 m after sunrise, was not late enough by 1 h. 55 m. We now therefore try for 23 h. 49 m. :—

	a.	*b.*	*c.*
Values (found) for sunrise	4484	423	282
Values for 23 h. (*Table V.*)	+ 325	35	3
Values for 49 m. (*Table V.*)	+ 12	1	0
	4821	459	285
Equation *b*	176		
Equation *c*	2		
t =	4999		

This is close enough to 5000, and we may take the mean-time ending of the tithi as 23 h. 49 m. after sunrise ; or we may add 1, or $4\frac{1}{4}$ m., to the mean-time, making the ending 23 h. 53 m. We cannot be absolutely certain, by this method of calculation, which result is the correct one ; for all the five terms which have been added together under the heading *a* to produce the final result *t* consist of whole figures with the fractions omitted, and in the end it can only be said that the result is exact within one

unit, or $4\frac{1}{4}$ m., either way, the difference rarely amounting to two units, or $8\frac{1}{2}$ m. All close cases should be examined by Prof. Jacobi's *Special Tables* (*Epig. Ind., I.*).

In future I only take note as a rule of the first approximation, as it is needless to work every example further than this. But the full process must be carried through whenever the first approximation brings us near to sunrise. See, for an instance, Example 23 below.

EXAMPLE 21.—*Another example of the same. A year with a "true" intercalated lunar month.*

Rule. The work is precisely the same; but in calculating the number of tithis or days to the given tithi or day from the first civil day of the luni-solar year, Chaitra śukla 1st, we must, if the given tithi belongs to a lunar month later than the month shown as intercalated in cols. 8 or 8A of Table I. (*Ind. Cal.*), add a month of 30 tithis to the interval.

Wanted the European day, week-day, and time corresponding to mean sunrise of the day described in an inscription as "Sunday, the 9th tithi of the dark fortnight of [amānta] Phālguna in Śaka 1124 expired."

The year (*see Table I.*) was K.Y. 4303 expired, A.D. 1202–3. Vaiśākha was the intercalated lunar month. The interval to the end of Māgha as given in Table III., col. 3, is 330 tithis, but in this year was 360 tithis because of the intercalation. Add 15 tithis of the bright half of Phālguna and 8 tithis of the dark half, total 23. Grand total 383 tithis, or $(383 - \frac{383}{64})$,[1] = 377 days approximately. Working for this interval we find it correct.

	d.	w.	a.	b.	c.
A.D. 1202 Chaitra śuk. 1 (*Table I.*) sunrise . . 25 Feb.	(56)	2	239	939	203
377 days (*Table IV.*)	(377)	6	7664	682	32
Sunrise, 377 days after Ch. śuk. 1	(433)	1	7903	621	235
Equation *b* (*Table VI.*)			43		
Equation *c* (*Table VII.*)			0		
t =			7946		

433 (*Table IX.*) = March 9th, of the following A.D. year. 1 = Sunday. *t* = 7946 shows (*Table VIII.*) that the 9th krishṇa tithi of Phālguna was current at mean sunrise.

Answer. The sunrise in question was that of Sunday, March 9th, A.D. 1203.

The beginning and ending of the tithi can be calculated as in the last example.

EXAMPLE 22.—*Another example.* Wanted in European reckoning the time of the occurrence of full-moon in amānta Mārgaśīrsha of K.Y. 3401 expired. (There was no added month in this year.)

The given year = A.D. 300–1. Full-moon day is the 15th śukla tithi. Interval from Chaitra śukla 1st to the 15th tithi in Mārgaśīrsha = (to end of Kārttika, by Table III., col. 3, 240 tithis + 14 tithis in Mārg.) 254 tithis or $(254 - \frac{254}{64})$ 250 days.

	d.	w.	a.	b.	c.
(*Table I.*) A.D. 300 Chait. śuk. 1, sunrise . 8 Mar.	(68)	6	9981	896	255[2]
250 days (*Table IV.*)	(250)	5	4658	73	684
Sunrise, 250 days after Ch. śuk. 1	(318)	4	4639	969	939
Equation *b* (*Table VI.*)			113		
Equation *c* (*Table VII.*)			83		
At mean sunrise, *t* =			4835		

318 = (*Table IX.*), the year A.D. being a leap-year, November 13th. 4 = Wednesday. At

[1] See *Indian Calendar*, § 139, p. 77, note 4.

[2] There is a misprint in Table I. The entries in cols. 21 to 25 against this year (p. iii.) should be respectively 35, ·105, 9981, 896, 255.

mean sunrise the tithi-index was 4835. The tithi therefore expired, and the moment of full-moon occurred (*Table VIII.*) at (5000 — 4835) 165 after sunrise, which (*Table X.*) = (7 h. 5 m. + 4 h. 36 m.) 11 h. 41 m. We work for this interval, the details for which are to be added to those for sunrise :—

	a.	b.	c.
At mean sunrise November 13th, A.D. 300	4639	969	939
11 h. (*Table V.*)	155	17	1
41 m. (*Table V.*).	10	1	0
	4804	987	940
Equation *b*	128		
Equation *c*	83		
t =	5015		

(*t* =) 5015 shows that the moment of full-moon was (*t* =) 15 earlier, or (*Table X.*) 1 h. 4 m. earlier than the hour already obtained, viz., 11 h. 41 m. after sunrise. We consequently, desiring absolute accuracy, test the result again for an interval from sunrise of (11 h. 41 m. — 1 h. 4 m.) = 10 h. 37 m.

	a.	b.	c.
At mean sunrise November 13th, A.D. 300	4639	969	939
10 h.	141	15	1
37 m.	9	1	0
	4789	985	940
Equation *b*	127		
Equation *c*	83		
	4999		

This is correct all but (*t* = 1, or) 4 minutes, and therefore we have for final result that the full-moon moment of Mārgaśīrsha in the year corresponding to A.D. 300–1 (K.Y. 3401 expired) occurred at from 10 h. 37 m. to 10 h. 41 m. after mean sunrise on Wednesday, November 13th, A.D. 300.

[Turning to my "*Eclipses of the Moon in India*" (*Table E, p.* i, *cols.* 1, 2, 3), it will be seen that according to advanced modern science (von Oppolzer's *Canon der Finsternisse,* adapted to Laṅkā mean time for India) there was a total eclipse of the moon on that day, the moment of full-moon being stated as 10 h. 34 m. mean time on the meridian of Laṅkā.]

EXAMPLE 22A.—(*The example given by Prof. Jacobi in "Ind. Ant." XVII., p.* 155.) Was there a lunar eclipse in Śrāvaṇa, A.D. 1144?

I work this by my method. We want the moment of full-moon in lunar Śrāvaṇa. Turning to Table I. we find that the Hindū year, = K.Y. 4245 expired, was a common one, and we take the details for Chaitra śuk. 1st, mean sunrise. (*Cols.* 19–25.) We find the interval from that moment to mean sunrise of the full-moon day of Śrāvaṇa, *i.e.*, the 15th śukla tithi, as near as we can guess it; thus, to end of Āshāḍha 120 tithis (*Table III., col.* 3) + 14 tithis in Śrāvaṇa; total 134 tithis = 132 days.

	d.	w.	a.	b.	c.
A.D. 1144 Chait. śuk. 1 (*Table I.*)	7 March (67)	3	47	501	233
Interval 132 days (*Table IV.*)	(132)	6	4699	790	361
	(199)	2	4746	291	594
Equation *b* (*Table VI.*)			276		
Equation *c* (*Table VII.*)			94		
		t =	5116		

199, the English year being a leap-year = July 17th. 2 = Monday. At mean sunrise that day t = 5116 (Jacobi calculates it as 5115). The moment of full-moon (5000) was 116 (=, by Table X., 7 h. 5 m. + 1 h. 8 m.) = 8 h. 13 m. before mean sunrise on Monday, or at 15 h. 47 m. Laṅkā time on Sunday, July 16th, A.D. 1144.

Professor Jacobi remarks that "it is likely there was a small lunar eclipse," and refers readers to von Oppolzer's *Canon der Finsternisse*. My own small volume, "*Eclipses of the Moon in India*," [1] now contains all the information required, as it gives von Oppolzer's own figures converted to Indiân, Laṅkā, time. Table E of that work shows that on Sunday, July 16th, A.D. 1144, there was an eclipse of the moon measuring 2.5 (in twelfths), and that von Oppolzer's determination of the moment of greatest phase, stated in Laṅkā time, is precisely the very moment determined by our own work above, viz., 15 h. 47 m. after mean sunrise. Continuing the calculation for absolute accuracy I find that the Hindū system fixes 15 h. 51 m., or 4 minutes later, as the moment of greatest phase.

This exact correspondence between Hindū computation and modern European science, while it is interesting, is not always to be looked for; though in lunar calculations we need never expect serious divergence, and it must not be forgotten that the time of occurrence of eclipses would generally be computed locally, *i.e.*, taking count of the difference in latitude and longitude between Laṅkā and the principal place in the neighbourhood of the calculator.

EXAMPLE 23.—*To find whether a true tithi is repeated* (*adhika*) *or suppressed* (*kshaya*).

Rule. Find, by the method shown in the last example, the tithi-index (t) at sunrise of the civil day concerned, and the beginning and ending times of the tithi then current. If the current tithi, which began before sunrise of that day, is also current at the next sunrise, so that the sun rose twice on it, it is added or repeated (*adhika*). If the tithi current at sunrise ended very shortly after sunrise, and the next tithi, beginning after sunrise and ending before the next sunrise, was therefore current at no sunrise, the latter tithi is expunged (or becomes *kshaya*). Sunrise was probably, for local almanacs, calculated as true or apparent sunrise, but for purposes of our general Tables is taken as mean sunrise. The "repetition" or "expunction" of a tithi does not concern the duration of the tithi itself, which always runs its course; but merely concerns the nomenclature of the civil day which takes its name from the tithi current at sunrise. (*Text, "Adhika and kshaya tithis,"* §§ 86-89, "*Hints,*" *Nos.* 15, 16.)

As an example we examine the adhika tithi noted in the Pañchāṅg extract on pp. 14, 15 of the *Indian Calendar*. We examine, that is, the tithis connected with the sunrises on the 11th, 12th and 13th September, A.D. 1894 (New Style), corresponding to the 12th, first 13th, and second 13th tithi of the bright or first fortnight of amānta Bhādrapada in Śaka 1817 current. The days concerned were Tuesday, Wednesday and Thursday. We accept the Pañchāṅg as accurate. The times are given in ghaṭikās and palas, and we convert them to hours and minutes by Table XXV. The 12th śukla tithi ended on the Tuesday at 56 gh. 44 p., or at 22 h. 42 m. after sunrise. The 13th tithi, that is, began at that moment, or at 1 h. 18 m. *before* sunrise on the Wednesday. It ended at 1 gh. 23 p., or 33 m. *after* sunrise on Thursday. It was therefore current on the two sunrises of Wednesday and Thursday. It had to give its number to both Wednesday and Thursday. Wednesday was connected with the "first 13th" śukla tithi and Thursday was connected with the second tithi of the same number, or the "second 13th." The first is generally called the "adhika 13th" and the second the "nija 13th." The 14th tithi was current at sunrise on the Friday, ending 5 gh. 18 p., or 2 h. 7 m. later, and it gave its number to that Friday.

[1] Published ten years later.

Calculation by our Tables (which are always framed for mean sunrise) for the sunrise of the Wednesday concerned, or September 12th, A.D. 1894, is as follows:—

	d.		w	a.	b.	c.
Chaitra śuk. 1 (*Table I., cols.* 19–25) . .	7 April	(97)	0	296	802	265
Interval to Bhādr. śuk. 13, 150 tithis to end of Śrāvaṇa + 12 expired tithis in Bhādr. = 162 tithis = 158 days = (*Table IV.*) .		(158)	4	3504	734	433
At sunrise on (255 =, *by Table IX.*) Wed., Sept. 12th		(255)	4	3800	536	698
Equation *b* (*Table VI.*)				109		
Equation *c* (*Table VII.*)				118		
			$t =$	4027		

Accordingly (*Table VIII.*) the 13th tithi began (4027 — 4000) at 27, or (*Table X.*) 1 h. 55 m. before sunrise on Wednesday and ended (4333 — 4027 =) at 306, or (*Table X.*) 21 h. 42 m. after sunrise. Continued calculation, however, for very accurate results shows that the 13th tithi began at 2 h. 4 m. before sunrise on Wednesday and ended at 23 h. 54 m., or six minutes before sunrise on the Thursday; so that by our Tables this 13th tithi would have been regular and not adhika, since it did not touch the Thursday sunrise.

This example shows how careful epigraphists have to be when calculating. The difference of longitude between Laṅkā (E. long. 75° 46′) and Poona (E. long. 73° 55′) causes the 13th tithi, which—calculating as all our Tables do for the longitude of Laṅkā, we have found to have ended six

N.B. minutes *before* sunrise on the Thursday—to have ended at Poona *after* sunrise on that day; since to its ending-time we have to add 8 m. for longitude (*Table XI.*). While it ended at 23 h. 54 m. on the Wednesday at Laṅkā, it ended at 0 h. 2 m. on the Thursday at Poona; and therefore, whereas at Poona the 13th tithi was repeated, it would not have been so at Laṅkā. At Poona the second 13th tithi was associated with the civil day beginning at mean sunrise on September 13th, since it was current at that moment. At a place on the meridian of Laṅkā, however, the civil day September 13th would have been coupled regularly with the 14th tithi, which was actually current at mean sunrise on that day. To put the case in another way:—At the time when at Laṅkā the hour was 6 a.m. it was 5.52 a.m. at Poona, and, since the 13th tithi ended at 5.54 a.m., it was current at mean sunrise at Poona, but not at Laṅkā.

Another reason for a difference in results is that while we follow throughout the *Ārya* and *Sūrya Siddhāntas*, the Poona almanack-makers have for many years past been including in their calculations certain corrections introduced in the 16th century by Gaṇēśa Daivjña (*Ind. Cal., p.* 13, *note* 2), and this practice is general in the Mahratta country. The example is therefore instructive. It shows how different results may arise from differences in local practice, and proves the necessity of careful calculation when the first approximate result arrived at shows that a tithi began or ended very close to sunrise.

We continue our examination of this Pañchāṅg for the kshaya or expunged tithi in the second fortnight of the same month. We work for the moon's age at the three successive sunrises of the 21st, 22nd and 23rd September, Friday, Saturday and Sunday.

	d.		w.	a.	b.	c.
As before. Chait. śuk. 1st (*Table I., cols.* 19–25)	7 April	(97)	0	296	802	265
Interval to Bhādr. kṛ. 6, 150 tithis to end of Śrāvaṇa + 20 expired tithis in Bhādr. = 170 tithis = 167 days (*Table IV.*) . . .		(167)	6	6552	61	457
At sunrise on (264 =) September 21st, Friday		(264)	6	6848	863	722
Equation *b* (*Table VI.*) . . .				34		
Equation *c* (*Table VII.*) . . .				120		
			$t =$	7002		

The 6th kṛishṇa tithi ended (*Table VIII.*) at (7002 — 7000 = 2 =) 9 m. (*Table X.*) before sunrise on the Friday, and at that sunrise the 7th kṛishṇa tithi was current. Now the Pañchâṅg states that the 6th kṛishṇa tithi lasted till 0 gh. 16 p., or till (*Table XXV.*) 6 m. 24 s. *after* sunrise on that day when the 7th tithi began. This 7th tithi ended at 55 gh. 18 p., or (*Table XXV.*) 22 h. 7 m. 12 s. on the same day, *i.e.*, at 1 h. 53 m. *before* the next sunrise, being therefore expunged, since no sunrise occurred on it. But according to *Indian Calendar* calculation the 7th tithi had begun very shortly before the Friday sunrise, and consequently was not expunged since a sunrise occurred in it. We therefore examine the state of things at the sunrise of the previous day, Thursday, by our method. We deduct from the *a*, *b*, *c* of Friday sunrise, the *a*, *b*, *c* for one day :—

	a.	*b.*	*c.*
At sunrise on September 21st, Friday	6848	863	722
Deduct for one day (*Table IV.*)	− 339	− 36	− 3
At sunrise on September 20th, Thursday	6509	827	719
Equation *b* (*Table VI.*)	16		
Equation *c* (*Table VII.*)	120		
t =	6645		

By Table VIII. we learn that the 5th tithi was current at sunrise on Thursday, expiring (6667 — 6645 = 22 =) 1 h. 34 m. after sunrise. At that moment the 6th tithi began, and we have seen that it ended 9 m. before sunrise on the Friday. No sun therefore rose on it. By *Indian Calendar* calculation for Laṅkâ, therefore, it was the 6th and not the 7th kṛishṇa tithi that was expunged.

We find, therefore, a difference here between *Indian Calendar* results and the results obtained by the Poona calculators of A.D. 1894 of about 15 minutes, which difference causes the expunction of a different tithi by the two methods.

I could have illustrated the method of work in this example in perhaps an easier manner, but thought it well to give a practical demonstration of how differences arise in these cases. The work itself is quite simple.

Mean lunar months and tithis.

Example 24.—*To find the time of beginning and ending of a mean tithi in a mean lunar month.* See the Rule and fully worked example given above (§§ 90–92). I give another example here from a fairly early inscription (*Ind. Ant., XXIV., p. 2, No.* 127), viz., a record of Bappuvarasa from a place near Bâdâmi. The given date is Śaka 856 expired, in the year called Jaya, Wednesday, the 5th of the bright half of the month Kârttika.

Rules for work are given in the text, §§ 91, 92. We work by the second of these.

The given year, Ś. 856 = A.D. 934–35. From Table I., cols. 19 to 25, we take the value of *a* at mean sunrise on the first day, Chaitra śukla 1st, of the given luni-solar year, together with the equivalent day and week-day of the Christian year ; we add to this *a* the constant, 201 ; add to this from Table IV. the *a* for the number of days intervening between Chaitra śukla 1st and the given day ; and thus obtain the *a* for mean sunrise on the given day. Table VIII., cols. 2, 3, shows which tithi

was current, and, with Table X., yields the mean-time of its beginning and ending. Thus, in the present case—

	d.	w.	a.
Chaitra śuk. 1st (*Table I.*), sunrise	19 Mar. (78)	4	(25+201=)226
For interval of 211 days to Kārtt. śuk. 5; *i.e.*, to end Āśvina 207 + 4 days in Kārttika (*Table IV.*) . .	(211)	1	1451
Sunrise 211 days later	(289)	5	1677
1677 (*Table VIII.*) gives śuk. 6. This shows that the estimate of the interval in days is too large, and we reduce it by one day (*Table IV.*)	— 1	— 1	— 339
Sunrise 210 days later	(288)	4	1338

a = 1338 (*Table VIII.*). This shows a current 5th śukla tithi as given. 288 = (*Table IX.*) October 15th. 4 = Wednesday.

Therefore we learn, roughly, that, by the system of mean lunar months, the given 5th śukla tithi of Kārttika of the given year was current at mean sunrise on Wednesday, October 15th, A.D. 934. This tithi began (*Table VIII.*) (1338 — 1333 =) 5 = (*Table X.*) 21 m. before mean sunrise; and ended (1667 — 1338 =) 329 = 23 h. 19 m. later.

We now test this result by the slightly more accurate rule given first in § 92 above. Assuming, as already found, that by the mean system, the value of *a* at mean sunrise of Chaitra śukla 1st (Wednesday, March 19th, day 78, A.D. 934) was 226, we find from Table X. that this = 14 h. 10 m. + 1 h. 51 m. = 16 h. 1 m. Hence the mean new-moon of Chaitra of the corresponding Hindū year took place at 16 h. 1 m. before mean sunrise on that day, viz.: on (3) Tuesday, March 18th, day 77, at 7 h. 59 m. after mean sunrise. The interval from this moment to the mean new-moon of Kārttika is (*Table XXI.*) 206 d. 17 h. 8 m.

	d.	w.	h.	m.
Chaitra mean new-moon	18 Mar. (77)	3	7	59
Interval to Kārttika mean new-moon (*Table XXI.*) .	(206)	3	17	8
Kārttika mean new-moon	(284)	0	1	7

284 = (*Table IX.*) October 11th, A.D. 934. 0 = Saturday. The new-moon of Kārttika occurred on this day at 1 h. 7 m. after mean sunrise. Four tithis intervened between this moment and the beginning of the 5th tithi. We therefore add the collective-duration given in Table XXI. for four mean tithis :—

	d.	w.	h.	m.
Mean new-moon of Kārttika	284	0	1	7
Interval of four tithis	3	3	22	30
End of the 4th tithi	287	3	23	37

287 = October 14 (*Table IX.*). 3 = Tuesday. On this day the 4th śukla tithi ended at 23 h. 37 m. Laṅkā time, or 23 minutes before mean sunrise on Wednesday, October 15th.

We thus find two minutes' difference between the two methods of calculation, the latter being the more accurate.

We are now able to discuss the question of the reliability and accuracy of the date as quoted in the record. Working by true months and tithis Professor Kielhorn found (*Ind. Ant., XXIV., p.* 2, *No.* 127), and (as I have proved independently) with perfect accuracy, that the quoted 5th śukla tithi of Kārttika in the given year began 2 h. 42 m. *after* mean sunrise on Wednesday, October 15th; so that properly speaking (unless there were any special reason, which in this case does not appear, for departing from the usual custom) this 5th tithi should not have been coupled with the civil day Wednesday.

Working by mean months and tithis we have found that this tithi began before mean sunrise on Wednesday; it was current at that sunrise; and was regularly coupled with Wednesday.

Therefore, though there is no proof of the fact, it is *possible* that the calculator of the date worked by mean lunar months and tithis in this case. The case may be compared with the date examined above (§ 92), viz.: the date of a record of the year A.D. 989, 55 years later.

N.B. [These cases must at present be considered as isolated ones. A long course of study is necessary before any certainty can be arrived at as to when and in what localities the mean system gave way to the true system of calculation. In each of these instances there may possibly have been some special reason (not, however, at present discernible) for coupling, under the true system, a true tithi with a day on whose sunrise it was not current. (On this subject see remarks by Prof. Kielhorn, *Ind. Ant.*, 1897, 177 ff.)]

Tithis coupled with dates in solar months.

EXAMPLE 26.—*To prove a date where a tithi is coupled with a solar month.* I take a Chōḷa date from the Tanjore District in Southern India as an example.[1] The king's given (10th) regnal year corresponds to either A.D. 1187 or 1188, the first year of the reign having begun between the 6th and 8th July, A.D. 1178. The solar month named is Karka, and therefore it may belong either to 1187 or 1188, since a day in Karka may be before July 6–8 or after it. We have to determine that point. The rest of the date is Saturday, the 12th śukla, or bright half, of an unspecified lunar month, the nakshatra being Mūla. The authority to be used is the *Ārya Siddhānta*.

Rule. We work by the rules given above for true nirayaṇa saṁkrāntis and for true lunar months and tithis. First find the initial civil day of the given solar month by finding the moment of its initial saṁkrānti (*Example* 11), and applying the appropriate local rule (*above*, § 43). If the given date is regular the lunar date must correspond with one of the days of this solar month. We therefore find the tithi current at mean sunrise of the first day of the solar month (*Example* 20); note the interval in whole days between that tithi and the given tithi; apply the *a*, *b*, *c* (*Table IV.*) for those intervening days to the *a*, *b*, *c* of the former tithi; and so find the *a*, *b*, *c* for the latter, or given tithi, at sunrise. With those figures we can calculate any nakshatra, yōga, or karaṇa given in the date.

First take Karka in the year A.D. 1187 = K.Y. 4288 expired, 4289 current.

	d.	*w.*	*h.*	*m.*
Mēsha saṁk. by *Ārya Siddh.* (*Table I.*)	(84)	4	1	47
Interval to Karka saṁk. (*Table XVIII.A*)	(93)	2	22	24
Karka saṁkrānti	(178)	0	0	11

(178) = June 27th, 0 = Saturday. On this day the Karka saṁkrānti occurred at 11 m. after mean sunrise. According to all rules this Saturday was the first civil day of Karka. We want the *a*, *b*, *c* for this Saturday at sunrise.

	d.	*w.*	*a.*	*b.*	*c.*
Civil day of Chaitra śuk. 1st (*Table I.*)	(72)	6	293	678	246
Interval of 178 — 72 days = 106 days (*Table IV.*) .	(106)	1	5895	847	290
At mean sunrise on June 27th, Saturday	(178)	0	6188	525	536
Equation *b*			118		
Equation *c*			74		
		t =	6380 = 5th kṛ. (*Table VIII.*)		

[1] Epig. Ind. X., p. 127, No. 168.

At mean sunrise on that Saturday the 5th kṛishṇa was the current tithi. The given tithi is the 12th śukla, and the interval between these two is 22 tithis, or about 21 days.

	d.	w.	a.	b.	c.
(*As above*). At mean sunrise, June 27th	(178)	0	6188	525	536
Interval (*Table IV.*) 21 days	+ (21)	0	7111	762	57
	(199)	0	3299	287	593
Equation *b*			276		
Equation *c*			94		
	$t =$		3669 = 12 śukla		

(*Table VIII.*)

This, 12th śukla, was the given tithi. It began, as will be seen in Table VIII., at ($t =$) 3667, or 9 minutes (*Table X.*) before sunrise on (0 =) Saturday, (199 =) July 18th, A.D. 1187. June 27th having been the 1st Karka, July 18th was the 22nd Karka.

For the nakshatra (*Example* 43 *below*) at sunrise that day we have—

(*c.*) 593 × 10 = ...	5930
Add Constant	7207
	3137
Deduct Equation c = ...	− 94
	3043
Add t = ...	3669
n = ...	6712

6712 shows that (*Table VIII., col.* 8) Mūla was the nakshatra at sunrise.

The date as given is therefore entirely correct for July 18th, A.D. 1187. It could not be right for 1188, because the week-day would be wrong. It is not necessary to decide as to which lunar month the given tithi belonged, but if desired this can be got from Table III. We found 106 days interval between Chaitra śuk. 1st and June 27th, and 21 days thence to the day of the given tithi; total, 127 days. Table III., col. 3A, shows that lunar Āshāḍha ended and Śrāvaṇa began after about 118 days from the beginning of the year, so the 12th śukla in question belonged to the lunar month Śrāvaṇa.

True intercalations and suppressions of lunar months.

EXAMPLE 27.—*To find, by the Ārya Siddhānta, if a true lunar month was intercalated or suppressed.* (*a*) *A common year.*

(See above, §§ 95 to 103, "Intercalations and suppressions of lunar months.") If a lunar month is stated in an inscription-date as intercalated, or if one appears to have been suppressed, it must be examined as directed in the examples which follow. The present examples are intended to test luni-solar years with a view to ascertaining whether they contained an intercalation or suppression of a month.

Rule. Find the *a*, *b*, *c* of true Mēsha saṁkrānti according to the *Ārya Siddhānta* in the given year by adding to the *a*, *b*, *c* of sunrise on Chaitra śukla 1st (*Table I., cols.* 19–25) the values of *a*, *b*, *c* given in Tables IV. and V. for the number of days, hours and minutes intervening between that day and the moment of Mēsha saṁkrānti as given in Table I., cols. 13 and 17, or as found by Example 3 above.

If the *a* of true Mēsha saṁkrānti is found to be less than 5910 the year cannot contain any intercalation or suppression. (*See* "*Hints*," *No.* 13, ii.)

We require to know if there was any intercalation or suppression of a month in K.Y. 3870 expired, A.D. 769–770 :—

		a.	b.	c.
At sunrise on Chait. śuk. 1., Day 72 (*Table I., cols.* 19, 23–25) . .		1	897	258
Interval to moment of Mēsha saṁkrānti, Day 79 (*Table I., cols.* 13, 17), 7 d. 22 h. 42 m. 7 days (*Table IV.*)	2370			
	2371			

We need go no further. The greatest increase of *a* for odd hours and minutes (*Table V.*) is (339 + 14) 353, and we see at once that in this case *a* at Mēsha saṁkrānti must be less than 5910 ; so that there could be no intercalation or suppression of a month in this year.

EXAMPLE 28.—*The same.* (*b*) *Year with an intercalated month.*

Rule. I assume that you are examining the conditions of the year, either (i.) to test a date which states that a given lunar month was intercalated, or (ii.) to test a year in order to see whether any month was intercalated or suppressed in it. Begin, as in the last example, by finding the values of *a, b, c* at the moment of Mēsha saṁkrānti by the *Ārya Siddhānta*. This done, and, finding that *a* is between 5910 and 10,000, so that an intercalation of a lunar month is possible, proceed as follows :—In case (i.) turn to Table XVIII.A, find the stated month in col. 1, and note the two solar saṁkrāntis with which it is connected in col. 2. Add to the *a, b, c* of the Mēsha saṁkrānti the increase of *a, b, c* as noted in col. 5 against the first of the two saṁkrāntis. This gives the *a, b, c* of the first of the two saṁkrāntis. Add to the total *a, b, c* so found the increase of *a, b, c* given in col. 8 from the first to the second of the two saṁkrāntis in col. 2. This gives the *a, b, c* at the moment of the second saṁkrānti concerned. Take from Tables VI. and VII. the equations of *b* and *c*, and add them to the *a* of each of the two saṁkrāntis, which gives the *t* for each, or tithi-index. If the *t* of the first saṁkrānti was near to but less than 10,000, and if the *t* of the second was near to but greater than 0, then the moon was waning at the first and waxing at the second saṁkrānti ; there was no saṁkrānti in the limits of the included lunar month, and that month was therefore intercalated. If the reverse was the case, *i.e.*, if the *t* of the first saṁkrānti was near to but greater than 0, while the *t* of the second saṁkrānti was near to but less than 10,000, then the moon was waxing at the first and waning at the second saṁkrānti ; there were two saṁkrāntis in the included month, and therefore that month was suppressed. In case (ii.), with the same Table XVIII.A select a saṁkrānti whose *a, b, c* (col. 5), when added to the *a, b, c* of Mēsha saṁkrānti as found, will be likely to result in a *t* near to but less than 10,000, and, considering that saṁkrānti as the first of the two connected with the possibly intercalated or suppressed lunar month, work as before for the *t* of that and the next following saṁkrānti. If for the reasons given above the month appears to be common, *i.e.*, neither intercalated nor suppressed, then the month shortly before or shortly after it will be found, probably, to have been either intercalated or suppressed. The *a, b, c* values for the increase between each saṁkrānti given in Table XVIII., col. 8, easily enable the calculation for months before and after the originally selected one to be made, by simple addition or subtraction.

I give two examples of work, one under Case i. and one under Case ii.

(*Case i.*) Table I. shows that in K.Y. 3869 expired, A.D. 768–69, the lunar month Jyēshṭha was intercalated according to the *Sūrya Siddhānta*. Test it by the *Ārya Siddhānta.* (This is the year next preceding the one given in Example 27.)

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	a.	b.	c.
Chait. śuk. 1 (*Table I., cols.* 19, 23, 24, 25), Day 54, sunrise . .	9967	961	206
Interval to Mēsh. saṁk., Day 80. 16 h. 30 m. (*Table I., cols.* 13, 17). (80 — 54 =) 26 d.			
26 d. (*Table IV.*)	8804	944	71
16 h. (*Table V.*)	226	24	2
30 m. (*Table V.*)	7	1	0
At Mēsha saṁkrānti	9004	930	279
Interval to Vṛishabha saṁk. (*Table XVIII.A, col.* 5)	472	122	85
At Vṛishabha saṁkrānti	9476	52	364
Equation *b* (*Table VI.*)	186		
Equation *c* (*Table VII.*)	15		
t =	9677		

	a.	b.	c.
At Vṛishabha saṁkrānti (*as found*)	9476	52	364
Interval Vṛish. saṁk. to Mithuna saṁk. (*Table XVIII.A, col.* 8), added to *a, b, c* of Vṛish. saṁk.	634	140	86
At Mithuna saṁkrānti	110	192	450
Equation *b*	271		
Equation *c*	41		
t =	422		

At the Vṛishabha saṁkrānti $t = 9677$ shows that the moon was waning and nearing new-moon At the Mithuna saṁkrānti $t = 422$ shows that new-moon was past and the moon was waxing. There was therefore no saṁkrānti in the lunar month Jyēshṭha, which lay between the Vṛishabha and Mithuna saṁkrāntis, and it was repeated, the intercalated month being called Adhika, or additional, Jyēshṭha and the real month Nija, or true, Jyēshṭha. (*See above*, § 97.)

(*Case ii.*) It is desired to ascertain whether the year K.Y. 3394 expired, A.D. 293–94, contained a true intercalated month by the *Ārya Siddhānta*.

(*See Example* 3 *above.*) 576 years + K.Y. 3394 = K.Y. 3970 expired, or A.D. 869–70, in which the time of Mēsha saṁkrānti by the *Ārya Siddhānta* is stated in Table I. as on March 21st, at 19 h. 32 m. Therefore the moment of Mēsha saṁkrānti in the given year, K.Y. 3394, was March 16th, at 19 h. 32 m. Laṅkā time.

(For the method of finding the *a, b, c* for this moment, see above, § 80 *ff.*)

In K.Y. 4394 expired, the 1st civil day of Chaitra began at sunrise on March 10th with $a = 89$, $b = 670$, $c = 237$. (*Table I., cols.* 19–25.) Add the differences for a period of 1,000 years, and we have the *a, b, c* values for March 10th, K.Y. 3394 expired (the given year), at mean sunrise.

	a.	b.	c.
Chaitra śuk. 1, at sunrise on March 10th, K.Y. 4394 expired . .	89	670	237
1,000 years' interval	4687	500	24
Chaitra śuk. 1, at sunrise on March 10th, K.Y. 3394 expired .	4776	170	261
Interval to March 16th, 19 h. 32 m., the moment of Mēsha saṁk., in K.Y. 3394 expired, 6 d. 19 h. 32 m.			
6 d. (*Table IV.*)	2032	218	16
19 h. (*Table V.*)	268	29	2
32 m. (*Table V.*)	8	1	0
At moment of Mēsha saṁkrānti	7084	418	279

	a.	*b.*	*c.*
(*Brought over*) . .	7084	418	279
Looking at Table XVIII.A, col. 5, we select, as the most likely month, Bhādrapada, because of the values of *a*, *b*, *c* for its two connected saṁkrāntis. Add, for Siṁha saṁkrānti	2465	551	343
At Siṁha saṁkrānti	9549	969	622
Equation *b* (*Table VI.*)	113		
Equation *c* (*Table VII.*)	103		
t =	9765		

	a.	*b.*	*c.*
At Siṁha saṁk. (as found)	9549	969	622
Add interval to Kanyā saṁk. (*Table XVIII.A, col.* 8)	510	126	85
	59	95	707
Equation *b* (*Table VI.*)	219		
Equation *c* (*Table VII.*)	119		
t =	397		

Thus the lunar month Bhādrapada was intercalated, since at the Siṁha saṁkrānti $t = 9765$ shows that the moon was still waning, and at the Kanyā saṁkrānti $t = 397$ shows that she was waxing. No solar saṁkrānti occurred in Bhādrapada, and it was repeated.

Example 29.—*The same.* (*c*) *Year with a suppressed month.*

Work by above rule for the year K.Y. 3871 expired, A.D. 770-71.

	a.	*b.*	*c.*
Chait. śuk. 1, Day 62 (*Table I.*)	216	781	230
Interval to Mēsha saṁk., Day 80. (80 — 62) = 18 d. 4 h. 55 m. (*Table I., cols.* 13, 17)—			
18 d. (*Table IV.*)	6095	653	49
4 h. (*Table V.*)	56	6	0
55 m. (*Table V.*)	13	1	0
At Mēsha saṁkrānti	6380	441	279
With Table XVIII.A, col. 5, we have to guess the saṁkrānti whose values of *a*, *b*, *c* will yield a *t* not exceeding 10,000, and we select Kanyā.			
Interval to Kanyā saṁk.	2975	677	428
At Kanyā saṁkrānti	9355	118	707
Equation *b*	235		
Equation *c*	119		
t =	9709		

	a.	*b.*	*c.*
Interval Kanyā saṁk. to Tulā saṁk., added to *a*, *b*, *c* at Kanyā saṁk. (as found)	9355	118	707
Interval to Tulā saṁk. (*Table XVIII.A, col.* 8).	313	106	83
At Tulā saṁkrānti	9668	224	790
Equation *b*	277		
Equation *c*	119		
t =	64		

At the Kanyā saṁkrānti $t = 9709$ shows that the moon was waning; at the Tulā saṁkrānti $t = 64$ shows that she was waxing. Therefore the lunar month Āśvina (*see Table XVIII., cols.* 1, 2) was intercalated.

We proceed as before, with the *a*, *b*, *c* for Tulā and for the interval to the next saṁkrānti, Vṛiśchika.

	a.	b.	c.
At Tulā saṁkrānti	9668	224	790
Interval from Tulā saṁk. to Vṛiśchika saṁk. (*Table XVIII.A, col.* 8)	125	85	82
At Vṛiśchika saṁkrānti	9793	309	872
Equation *b*	270		
Equation *c*	104		
t =	167		

Therefore lunar Kārttika was a common month.

Again—

	a.	b.	c.
At Vṛiśchika saṁkrānti	9793	309	872
Interval to Dhanus saṁkrānti	9993	71	81
At Dhanus saṁkrānti	9786	380	953
Equation *b*	236		
Equation *c*	78		
t =	100		

Hence the lunar month Mārgaśīrsha was a common one.

We proceed as before:—

	a.	b.	c.
At Dhanus saṁkrānti	9786	380	953
Interval to Makara saṁkrānti	9940	65	81
At Makara saṁkrānti	9726	445	34
Equation *b*	188		
Equation *c*	47		
t =	9961		

At the Dhanus saṁkrānti we have found that the moon was waxing. At the Makara saṁkrānti, t being $= 9961$, she was waning. So there were two saṁkrāntis in the lunar month Pausha, and it, Pausha, was consequently suppressed.

EXAMPLE 30.—*To find whether a lunar month was common, intercalated or suppressed, according to the Sūrya Siddhānta.* (*a*) *A common year.*

The work is precisely the same as by the *Ārya Siddhānta* in the three preceding examples, only (i.) instead of using Table XVIII.A for the collective duration of solar months from Mēsha saṁkrānti and for the length of each month between saṁkrāntis, Table XVIII.B has to be used; and (ii.) when the moment of Mēsha saṁkrānti according to the *Sūrya Siddhānta* is not given in Table I., but only that according to the *Ārya Siddhānta*, then the correction given for the year in Table XVII. must be applied in order to get the proper *Sūrya Siddhānta* figure.

Take the year given in Example 27, viz., K.Y. 3870 expired, A.D. 769–70.

	a.	b.	c.
Chaitra śuk. 1st, at sunrise March 13 (*Table I. cols.*, 23–25) . .	1	897	258
Interval to Mēsha saṁk., March 20, by the *Ārya Siddh.* (*cols.* 13–17), 7 d. 22 h. 42 m. + for the same by the *Sūrya Siddh.* (*Table XVII. for the year A.D.* 769), 30 m. Total, 7 d. 23 h. 12 m.			
7 d. (*Table IV.*)	2370		

We need go no further. The month was clearly a common one. (*See Example 27 and "Hints,"* 13, ii.)

EXAMPLE 31.—*The same.* (*b*) *An intercalated month.*

Try the year K.Y. 3869 expired, A.D. 768–69, as in Example 28. The process is similar:—

	a.	b.	c.
Chait. śuk. 1st, at sunrise (Day 54), (*Table I.*)	9967	961	206
Interval to Mēsha saṁk. (Day 80), 26 d. 16 h. 30 m. + (*Table XVII.*) 30 m. = 26 d. 17 h.—			
26 d. (*Table IV.*)	8804	944	71
17 h. (*Table V.*)	240	26	2
Interval to Vṛishabha saṁk. (*Table XVIII.B, col.* 5) . . .	475	123	85
At Vṛishabha saṁkrānti	9486	54	364
Equation *b*	187		
Equation *c*	15		
$t =$	9688		

	a.	b.	c.
Again: Vṛish. saṁkrānti	9486	54	364
Interval to Mithuna saṁk. (*Table XVIII.B, col.* 8) . . .	641	140	86
At Mithuna saṁkrānti	127	194	450
Equation *b*	271		
Equation *c*	41		
$t =$	439		

Since at the Vṛishabha saṁkrānti the moon was waning ($t = 9688$) and at the Mithuna saṁkrānti it was waxing ($t = 439$), the lunar month Jyēshṭha (*Table XVIII.B, col.* 1) was intercalated.[1]

[1] The figures respectively for *t* in the *Indian Calendar* (Table I., cols. 9, 11, p. XXX.) are for the *Sūrya Siddhānta* and are 9691 and 440. The calculation was made by a different method, and I prefer the present system as likely to be even more accurate than the other.

EXAMPLE 32.—*The same.* (*c*) *A suppressed month.*

Work for the year given in Example 29, viz., K.Y. 3871 expired. A.D. 770–71.

	a.	*b.*	*c.*
Chait. śuk. 1., Day 62 (*Table I.*)	216	781	230
Interval to Mēsha saṁk. by *Sūrya Siddh.*, 18 d. 4 h. 55 m. (as before) + (*Table XVII.*) 30 m. = 18 d. 5 h. 25 m.—			
18 d. (*Table IV.*)	6095	653	49
5 h. (*Table V.*)	71	8	1
25 m. (*Table V.*)	6	1	0
At Mēsha saṁk. by *Sūrya Siddh.*	6388	443	280 [1]
Select (as before) the Kanyā saṁk. (*Table XVIII.B, col.* 5).			
For the interval	2994	679	428
At Kanyā saṁkrānti	9382	122	708
Equation *b*	237		
Equation *c*	119		
t =	9738		

	a.	*b.*	*c.*
Again: Kanyā saṁk.	9382	122	708
For the interval Kanyā saṁk. to Tulā saṁk. (*Table XVIII.B, col.* 8)	308	105	84
At Tulā saṁkrānti	9690	227	792
Equation *b*	278		
Equation *c*	119		
t =	87		

As at the Kanyā saṁkrānti (*t* = 9738) the moon was waning and at the Tūla saṁkrānti (*t* = 87) she was waxing, there was no saṁkrānti in the lunar month Āśvina, and that month was repeated.

We proceed as before with the *a*, *b*, *c* for the Tulā saṁkrānti, and for the interval to the next saṁkrānti, Vṛiśchika.

	a.	*b.*	*c.*
Tulā saṁkrānti	9690	227	792
Interval to Vṛiśchika saṁk. (*Table XVIII.B, col.* 8)	122	85	81
Vṛiśchika saṁk.	9812	312	873
Equation *b*	269		
Equation *c*	104		
t =	185		

The lunar month Kārttika was therefore a common one, since the moon was waxing at both its beginning and end.

Proceed again:—

	a.	*b.*	*c.*
At Vṛiśchika saṁkrānti	9812	312	873
Interval to Dhanus saṁk. (*Table XVIII.B, col.* 8)	9986	70	81
At Dhanus saṁkrānti	9798	382	954
Equation *b*	235		
Equation *c*	78		
t =	111		

[1] *c* being always 279 at the Mēsha saṁkrānti, that figure may be substituted.

For similar reasons we find Mārgaśīrsha to be a common month.

Again :—

	a.	b.	c.
At Dhanus saṁkrānti	9798	382	954
Interval to Makara saṁk.	9928	64	81
At Makara saṁkrānti	9726	446	35
Equation b	187		
Equation c	47		
$t =$	9960		

The lunar month Pausha is thus proved to have been suppressed ; since the moon was waxing at the first saṁkrānti (t = 111) and waning at the second (t = 9960), so that there were two saṁkrāntis in Pausha.

[Continuation of work by the *Sūrya Siddhānta* for this year shows an intercalated Chaitra of the following year, with, at the Mīna saṁkrānti t = 9860, and at the Mēsha saṁkrānti t = 84. The figures differ slightly from those entered in Table I., cols. 9, 11, which were calculated by Prof. Jacobi's *Ind. Ant.*, Vol. XVII., Tables ; but the result is the same.]

EXAMPLE 33.—*To convert the result arrived at for a true intercalated or suppressed month according to the Sūrya Siddhānta into the same according to the Ārya Siddhānta.*

All the entries for both true and mean intercalated months in Table I. of the *Indian Calendar* are stated according to calculation made by the *Sūrya Siddhānta*, and begin with A.D. 300 ; but from about A.D. 500 to at least 1100 we require, for epigraphical purposes, the details as calculated by the *Ārya Siddhānta* for all India, while we also require the latter for South India during the whole period to A.D. 1900. For the years previous to about A.D. 500 there can be no certainty as to the authority by which calculations were made, nor, probably, in many places for a century or two subsequent to A.D. 500. So that it is important to be able easily to convert a result calculated by the *Sūrya* into a result according to the *Ārya Siddhānta*.

Rule. To a result calculated by the *Sūrya Siddhānta* (as in cols. 8 to 12, Table I., *Ind. Cal.*) apply Correction I. (*see above*, § 46) by use of Table XVII. with sign reversed, or by the Table on p. 55 of the *Indian Calendar* ; and Correction II. (*above*, § 55) by use of Table XVIII.C, col. 3, *a*, with sign reversed.

[*N.B.*—Note the remarks regarding the conversion of results for true months in the margin of Table XVIII.C, and in the text above, §§ 107–110, where it is shown that a result so converted is only correct within certain limits.]

Take the year K.Y. 3668 expired, A.D. 567–68. Table I., according to the *Sūrya Siddhānta*, shows (*cols.* 9, 11) the t of intercalated Śrāvaṇa to be at the first saṁkrānti 9648 and at the second saṁkrānti 455. We wish to know what these figures would be if calculation had been made by the *Ārya Siddhānta*.

The two saṁkrāntis are respectively Karka and Siṁha (*Table XVIII.C against "Śrāvaṇa" in col.* 1). We apply the two corrections as directed. Correction I. (*Table XVII.*) is, for each saṁkrānti (a =) — 2. Correction II. (*Table XVIII.C*) is, for Karka (a =) — 22, and for Siṁha (a =) — 25. This gives us, for Karka (9648 — 2 — 22) 9624, and for Siṁha (455 — 2 — 25) 428. These are the results according to *Ārya Siddhānta* calculation.

I have shown the reasons why we may expect a possible maximum variation of 6 in the case of these two saṁkrāntis. Actual calculation by the *Ārya Siddhānta* yields results, for Karka 9620, and for Siṁha 426.

EXAMPLE 34.—*The same. Case of a suppressed month. Results by the two Siddhāntas differ from one another.*

In K.Y. 4576 expired, A.D. 1475-76, Māgha was suppressed according to the *Sūrya Siddhānta* (*Table I., cols.* 8, 9, 11); the *t* for the first of its connected saṁkrāntis, Makara (*Table XVIII.C, col.* 2) being 16, and for the second, Kumbha, 9990. These figures being rather close to the new-moon points 0 and 10,000, we wish to know what the result would be if calculation were made by the *Ārya Siddhānta* :—

	1st saṁk. t.	*2nd saṁk. t.*
For Māgha. *Sūrya Siddhānta* (*Table I.*)	16[1]	9990
Corr. I. for A.D. 1476 (*Table XVII.*)	— 25	— 25
Corr. II. for Makara and Kumbha (*Table XVIII.C, col.* 3*a*) .	+ 6	+ 9
For Māgha by *Ār. Siddh.*	9997	9974

Thus by the *Ārya Siddhānta*, which was in use in South India at the given date, Māgha was a common month; and actual calculation proves that the suppressed month by that Siddhānta was the previous month Pausha, with, for the first saṁkrānti (Dhanus) $t = 83$, and for the second (Makara) the same figure that we have obtained, viz. ($t =$) 9997.

EXAMPLE 35.—*To convert the result arrived at for a true intercalated or suppressed month according to the Ārya Siddhānta into the same according to the Sūrya Siddhānta.*

The process is precisely the same, only the figures for Corr. I. (*Table XVII.*) and for Corr. II. (*Table XVIII.C*) are applied as they stand. There is no need to illustrate this. The case is the exact converse of the last two examples.

Intercalations of mean lunar months.

Use of Tables XIX.A, XIX.B

EXAMPLE 36.—*To find whether a mean lunar month was common or intercalated* (*adhika*) *according to the Ārya Siddhānta.* (*a*) *A common year.*

The method is similar to that used in the true method (*see Example* 27) but simpler, inasmuch as we work only by values of *a*, *i.e.*, the distance of the moon from the sun in mean longitude, which values yield at once a final correct result.

Rule. We take first the *a* of mean sunrise on Chaitra śukla 1st (*Table I., col.* 23), and add to it the values of *a* for the days, hours, and minutes elapsed between that date and the true moment of Mēsha saṁkrānti according to the *Ārya Siddhānta* (*Table I., cols.* 15, 17, *and Tables IV., V.*), thus obtaining the *a* for true Mēsha saṁkrānti. Convert this to mean Mēsha saṁkrānti by adding ($a =$) 727, the value of the śōdhya interval according to the *Ārya Siddhānta* (*above* § 58). Add to the result the constant ($a =$) 201 (*ibid.*). This gives the actual *a*, which is now equal to *t* and is exact for the moment of mean Mēsha saṁkrānti. Note in Table XIX.A (*cols.* 1 *and* 2) the two saṁkrāntis connected with the given or desired lunar month, and add to the total *a* obtained as above the *a* for the interval from Mēsha saṁkrānti to the first of those two saṁkrāntis (*Table XIX.A, col.* 5). Add to the last total the *a* for the interval between that saṁkrānti and the next following saṁkrānti (*Table XIX.A, col.* 6); and you have the *a* or *t* for both the saṁkrāntis connected with the lunar month under consideration. The result will show whether the lunar month was common or *adhika*, since the rules for mean are the same as for true intercalations in that respect. Note that there can be no intercalation in a year where the *a* of mean Mēsha saṁkrānti (after addition, that is, of the śōdhya 727 and the constant 201 to the *a* already obtained) is less than 6311; also that there can be no suppression of a mean month. (*Ind. Cal.*, § 47, *p.* 28. "*Hints,*" *No.* 14.)

[1] In such a case we take 16 as = 10,016.

Consider the year K.Y. 4019 expired, A.D. 918–19. (*Table I., pp.* xl., xli.)

	a.
At mean sunrise, Chait. śuk. 1 (*Table I., col.* 23) = Day 75 (*col.* 19)	44
Interval to true Mēsha saṁkrānti, Day 81 (*col.* 13) — 75 (*col.* 19) = 6 d. + 11 h. 45 m. (*col.* 17)—	
6 d. (*Table IV.*)	2032
11 h. (*Table V.*)	155
45 m. (*Table V.*)	11
Ārya Siddhānta śōdhya	727
Constant	201
At mean Mēsha saṁkrānti (*a* = *t* =)	3170

Since the *a* (or *t*) of mean Mēsha saṁkrānti was less than 6311 we know that no intercalation of a month was possible in that year.

EXAMPLE 37.—*The same.* (*b*) *A mean intercalated* (*adhika*) *month.* Work for the year K.Y. 4020 expired (A.D. 919–20), the year next to the one in Example 36:—

	a.
At mean sunrise, Chait. śuk. 1 (*Table I., col.* 23) = Day 64 (*col.* 19)	9920
Interval to true Mēsha saṁkrānti, 81 (*col.* 13) — 64 (*col.* 19) = 17 d. + 17 h. 57 m. (*col.* 17)—	
17 d. (*Table IV.*)	5757
17 h. (*Table V.*)	240
57 m. (*Table V.*)	13
Ārya Siddhānta śōdhya	727
Constant	201
At mean Mēsha saṁkrānti (*a* =)	6858

We expect this year an intercalation late in the year, (*a* =) 6311 being the outside limit; and we select as most probable, Phālguna.

Interval to mean Kumbha saṁkrānti (*Table XIX.A, col.* 5)	3073
At mean Kumbha saṁkrānti (*a* =)	9931
Interval to mean Mīna saṁkrānti (*Table XIX.A, col.* 6)	308
At mean Mīna saṁkrānti (*a* =)	239

At the first, Kumbha, of the mean saṁkrāntis concerned with mean lunar Phālguna, the moon was waning, *a* (or *t*) being 9931, and at the Mīna saṁkrānti (239) she was waxing; so there was no saṁkrānti in lunar Phālguna, and that month had to be intercalated.

EXAMPLE 38.—*To find whether a mean lunar month was common, or intercalated* (*adhika*) *according to the Sūrya Siddhānta.* (*a*) *A common year.*

First find the moment of Mēsha saṁkrānti according to the *Sūrya Siddhānta.* This is given in the *Indian Calendar,* Table I., for years subsequent to A.D. 1100. For earlier years apply (§ 46), Correction I. (*Table XVII. as it stands*) to the time given in Table I. for computation by the *Ārya Siddhānta,* or use the Table on p. 55 of the *Indian Calendar.* Then take the value of *a* for Chaitra śukla 1st, at mean sunrise, given in Table I., col. 23. Add to it the values of *a* for the interval of days, hours and minutes to the Mēsha saṁkrānti found. Add the śōdhya according to the *Sūrya Siddhānta,* viz., 734 (*above,* § 58), as well as the constant 201 (*ibid.*). This gives the correct *a* (or *t*) for the moment of mean Mēsha saṁkrānti. Add the *a* for the interval from the Mēsha saṁkrānti to the first of the two saṁkrāntis concerned (*Table XIX.B, col.* 5), and then the *a* for the interval to the second of these (*ibid., col.* 6). The two results show the *a* (or *t*) of the moon at each of these saṁkrāntis. The rule governing intercalations of mean months is the same as those of true months. (*See Examples* 28, 29, 30.)

Take the year K.Y. 4019 expired, A.D. 918–19 (*Table I., pp.* xl., xli.). The moment of true Mēsha saṁkrānti is given (*cols.* 13–17) according to the *Ārya Siddhānta* only, viz., March 22nd (81) at 11 h. 45 m. Convert this to *Sūrya Siddhānta* computation by adding 46 minutes (*Table XVII.*). Then, by the *Sūrya Siddhānta*, Mēsha saṁkrānti took place on March 22nd (81) at 12 h. 31 m. after mean sunrise. Chaitra śukla 1st was (*Table I., col.* 19) on March 16th (75), when at mean sunrise *a* was 44 (*col.* 23).

	a.
At mean sunrise, Chaitra śukla 1st = Day 75	44
Interval to true Mēsha saṁkrānti, (81 — 75) 6 d. 12 h. 31 m.—	
6 d. (*Table IV.*)	2032
12 h. (*Table V.*)	169
31 m. (*Table V.*)	7
At (*Sūrya Siddhānta*) śōdhya	734
Constant	201
At (*Sūrya Siddhānta*) mean Mēsha saṁkrānti	3187

Since this is below 6311, we know that no intercalation was possible in that year. ("*Hints*" *No.* 14.)

EXAMPLE 39.—*The same.* (*b*) *An intercalated* (*adhika*) *month.*

Work for the year K.Y. 4020 expired, A.D. 919–20. True Mēsha saṁkrānti by the *Ārya Siddhānta* (*Table I.*) was March 22nd (81), 17 h. 57 m. Correction I. (§ 46) = + 46 m. True Mēsha saṁkrānti by the *Sūrya Siddhānta* March 22nd (81), 18 h. 43 m.

	a.
At mean sunrise, Chaitra śukla 1. (*Table I., col.* 23) = Day 64 (*col.* 19)	9920
Interval to true Mēsha saṁkrānti, 81 d. (*col.* 13) — 64 d. (*col.* 19) = 17 d. + 18 h. 43 m.—	
17 d. (*Table IV.*)	5757
18 h. (*Table V.*)	254
43 m. (*Table V.*)	10
Sūrya Siddhānta śōdhya (§ 58)	734
Constant (§ 57)	201
At mean Mēsha saṁkrānti by *Sūrya Siddhānta* (*a* =)	6876
(As in Example 37, we select lunar Phālguna as the probably intercalated month.)	
Interval to mean Kumbha saṁkrānti (*Table XIX.B, col.* 5)	3074
At mean Kumbha saṁkrānti (*a* =)	9950
Interval to mean Mīna saṁkrānti (*Table XIX.B, col.* 6)	307
At mean Mīna saṁkrānti (*a* =)	257

Comparing these results, 9950 and 257, with the entries in Table I., p. xli. for the year (*cols.* 9*a* and 11*a*), which were obtained by a different process, we see that the only difference is one unit in the second figure, which stands at 258 in Table I. This sufficiently proves the accuracy of both methods. Mean Phālguna was intercalated (*adhika*) that year.

EXAMPLE 39A.—*To convert the result arrived at for a mean intercalated month by the Sūrya Siddhānta into the same according to the Ārya Siddhānta.*

(See note at beginning of introduction to Example 33.) Mean intercalated months by the *Sūrya Siddhānta* are given from A.D. 300 to 1100 in cols. 8*a* to 12*a* of Table I. of the *Indian Calendar.*

Rule. Apply Corrections I. (§ 46, *Table XVII. with sign reversed*) and III., which (*above* § 57), in terms of *a*, is — 8.

Thus, we find in the *Indian Calendar* (*Table I., cols.* 9*a*, 11*a*) during the year K.Y. 4020 expired = A.D. 919–20, a mean intercalated Phālguna by the *Sūrya Siddhānta* with, for its two saṁkrāntis, (*a*=) 9950 and 258. Correction I. (§ 46, *Table XVII.*) is (*a* =) — 11 for this year. Correction III. (§ 57) is — 8.

9950 — 11 — 8 = 9931. 258 — 11 — 8 = 239, and these are the figures as we found them by actual work in Example 37.

EXAMPLE 39B.—*To convert the result arrived at for a mean intercalation by the Ārya Siddhānta into a result by the Sūrya Siddhānta.*

This is the same but reversed.

Rule. Apply Correction I. (§ 46, *Table XVII. as it stands*), and Correction III. (§ 57) = + 8.

The *Ārya Siddhānta* result for K.Y. 4020 expired, A.D. 919–20, being a mean intercalated Phālguna with its two saṁkrāntis at *a* = 9931 and 239, we apply Correction I. for the year or (*a* =) + 11, and Correction III. = + 8. 9931 + 11 + 8 = 9950, and 239 + 11 + 8 = 258, the figures given for the *Sūrya Siddhānta* in the *Indian Calendar.* (*Table I., cols.* 9*a*, 11*a*.)

EXAMPLE 40.—*Calculation according to the Ārya Siddhānta by mean lunar months in a year following a year when, though there was no intercalation of a month by the "true" system, there was one by the mean system.*

For explanation, see above §§ 67–69, and Table XXIV.

Rule. Find the moment of true Mēsha saṁkrānti in the given year by Table I., or by Example 3 above. Add the śōdhya interval, viz., 2 d. 3 h. 33½ m. This gives the moment of mean Mēsha saṁkrānti, from which all mean computation for the year must begin. Table XXIV. gives (*cols.* 19 *and* 23) the day and the *a* at sunrise on that day, which is the first civil day of the luni-solar year, or Chaitra śukla 1st, for mean computation. Find the difference between sunrise on that day and the moment of mean Mēsha saṁkrānti as found. From Tables IV. and V. take the *a* for the interval and add it to the *a* of Chaitra śukla 1st at sunrise. Add the constant 201 (§ 57). This gives the *a*, which then = the *t* or tithi-index of mean Mēsha saṁkrānti. Table XIX.A gives the *a* of the interval between this point and each mean saṁkrānti (*col.* 5), as well as the *a* of the interval between each saṁkrānti and the next. This enables all work to be done for mean intercalations. For finding the moments of mean new-moons and mean tithis Table XXI. gives all particulars.

Work for the year K.Y. 4022 current, A.D. 920–21. Table I. shows (*p.* xli.) that true Mēsha saṁkrānti took place on March 22nd at 0 h. 10 m. Lanka time. Take the *Ārya Siddhānta* śōdhya as 2 d. 3 h. 32 m. Adding this to the former, we have mean Mēsha saṁkrānti on March 24th at 3 h. 42 m. Table XXIV. shows that the *a* of Chaitra śukla 1st, at mean sunrise on March 23rd was 9955. Add the *a* for 1 d. 3 h. 42 m. Thus—

	a.
At mean sunrise, Chait. śuk. 1	9955
Interval, 1 d. (*Table IV.*)	339
3 h. (*Table V.*)	42
42 m. (*Table V.*)	10
Constant (§ 57)	201
At mean Mēsha saṁkrānti	547

There can be no mean intercalation this year, nor was one expected, since one had taken place the previous year. But we may want to know the *a* or *t* of mean Mēsha saṁkrānti in order to test a day and tithi by the mean system; since from that point we obtain the *a* or *t* of every subsequent saṁkrānti in the year by use of Table XIX.A, and consequently of every solar day. Suppose, for example, we are concerned with śukla 8 of mean lunar Bhādrapada in this year. Bhādrapada ended after the Kanyā saṁkrānti. For this last (*Table XIX.A, col.* 5) we have (mean Mēsha saṁkrānti) 547 + (interval

to Kanyā) 1536 = 2083. This was (*Table VIII., col.* 3) śukla 7, since $a = t$ in mean calculations. Therefore śukla 8 was in mean solar Kanyā.[1] The actual time of the Kanyā saṁkrānti can be found as in Example 15, as also the week-day.

EXAMPLE 41.—*The same by the Sūrya Siddhānta.*

Rule. The process is precisely the same. When the time, by the *Sūrya Siddhānta*, of true Mēsha saṁkrānti is given in the *Ind. Cal.*, as it is in cols. 13, 14, 15*a*, 17*a*, from A.D. 1100, it is converted into the time of mean Mēsha saṁkrānti by the addition of the *Sūrya Siddhānta* value for the śōdhya, viz., 2 d. 10 gh. 14 p., or 2 d. 4 h. 6 m. When the time of true Mēsha saṁkrānti is not so given, as in the years from A.D. 300 to 1100, the time by the *Ārya Siddhānta* must be converted into the time according to the *Sūrya Siddhānta* by Table XVII. or Example 3, and then the śōdhya must be added. This gives the moment of mean Mēsha saṁkrānti by the *Sūrya Siddhānta*. If the śōdhya is to be added, not in time but in the value of *a*, the latter is 734.

I take the same year, K.Y. 4022 current, A.D. 920–921, as in the last example.

True Mēsha saṁkrānti by the *Ārya Siddhānta* occurred (*Table I.*) at 0 h. 10 m. after mean sunrise on Wednesday, March 22nd. Add 46 m. (*Table XVII.*). True Mēsha saṁk. by *Sūrya Siddh.* = 0 h. 56 m. on the same day. Add śōdhya 2 d. 4 h. 6 m. Mean Mēsha saṁk. by *Sūrya Siddh.*, Friday, March 24th, at 5 h. 2 m. Table XXIV. shows that the *a* of Chaitra śukla 1st, corresponding to mean sunrise of March 23rd, was 9955. The interval between the two was 1 d. 5 h. 2 m. Add the values of *a* for this, and the constant, 201. This gives the *a* (or *t*) for mean Mēsha saṁkrānti. The *a* (or *t*) of any date in the year can be got from this by use of Table XIX.B, and Table VIII.

	a.
At mean sunrise, Chait. śuk. 1 (*Table XXIV.*)	9955
Interval, 1 d. (*Table IV.*)	339
5 h. (*Table V.*)	71
2 m. (*Table V.*)	0
Constant (§ 57)	201
At mean Mēsha saṁkrānti	566

There can be no mean intercalation this year.

Suppose we desire to ascertain the tithi current at mean sunrise on the 14th day of the mean solar month Tulā (Kārttika) in that year by the *Sūrya Siddhānta*, and the European day corresponding.

	a.
At mean Mēsha saṁkrānti	566
Interval to mean Tulā saṁkrānti (*Table XIX.B*)	1844
At mean Tulā saṁkrānti	2410

Now, the mean Mēsha saṁk. was on Friday, March 24th (84)[2], at 5 h. 2 m. Interval in time to mean Tulā saṁk. (*Table XIX.B, col.* 4) 182 d. 15 h. 6 m. Therefore, the mean Tulā saṁk. took place on September 22nd (266) at 20 h. 8 m. The week-day was (6 + 0)[3] Friday. *See "Days of a civil month"* (§ 43, *above.*) By both the South-Indian rules (iii., iv.) the first civil day of Tulā began on Saturday, September 23rd. By the Orissa (ii.) rule it began on Friday, September 22nd. By the Bengal (i.) rule it began on Sunday, September 24th. It began at sunrise by all rules. I take the date as a South-Indian one, mean 1st Tulā beginning at sunrise on Saturday, September 23rd. Add 14

[1] Probably. But the first civil day of solar Kanyā may possibly have been as late as the 9th śukla. See "*Days of a civil month*" (§ 43, *above*). The civil beginning of the solar month must always be established by local rule.

[2] Table IX., A.D. 920 was a leap-year.

[3] Mean Mēsha saṁk. was on 6, Friday. The week-day for the 182 days' interval is + 0. (See the figure in brackets against 182 in Table XIX.B, or Table IV.)

(given) days. The given day was Saturday, October 7th. The mean Tulā saṁk. having been found to have taken place on September 22nd at 20 h. 8 m., the interval between it and mean sunrise (6 a.m.) on October 7th is 15 d. 3 h. 52 m.

	a.
At mean Tulā saṁk. (above)	2410
Interval, 15 d. (*Table IV.*)	5079
3 h. (*Table V.*)	42
52 m. (*Table V.*)	12
	7543

a, or *t* (by Table VIII.), being 7543 at mean sunrise, we find that by the mean system of computation, the 8th krishṇa was the then current tithi. The day was Saturday, October 7th = 14th Tulā, or solar Kārttika.

EXAMPLE 42.—*Another way of calculating the same.* I have shown in the last example how any date can be calculated when once the moment of mean Mēsha saṁkrānti in time and in terms of *a* has been found. The object is to get the *a* of mean Mēsha saṁkrānti and then work from it. We got this in the last two examples by the use of Table XXIV. But there is also another method to which recourse may be had. We are working by the system of mean intercalations, which depend on the moments of mean new-moons with reference to the moments of mean saṁkrāntis. Now, it is easy to see that, when there has been an intercalation of a mean lunar month in the year previous to the one under consideration, we can work by the *a* of Chaitra śukla 1st as given in Table I. if we remember to add a lunar month and work for a month next succeeding the given month instead of working for the given month. Instead of working by the *a* of the new Table for mean lunar Chaitra we can work for the *a* of mean lunar Vaiśākha by Table I. since both mean the same month.

Take, for instance, the year K.Y. 3412 current, and work as suggested. We want the *a* for the two saṁkrāntis connected, let us say, with the first month Chaitra by the mean system; and also the same for the third lunar month, Jyēshṭha. Now, remembering that, there having been a mean intercalation of Māgha in the previous year (*see Table I.*), the lunar months we are working for are the same as (Vaiśākha having been intercalated by the true system) First Vaiśākha (the second month of the true system) and Jyēshṭha (the fourth month of the true system), we can work for these latter months by Table I., and come to the same result.

NAKSHATRAS, YŌGAS, AND KARAṆAS. (§§ 112 ff.)

EXAMPLE 43.—*To find the nakshatra of the moon at a given moment.*

Rule. First find the *a*, *b*, *c*, and *t* at sunrise on the given day, or at the given moment of the day, by the examples given above, Nos. 20 to 22. Multiply the found value of *c* by 10 (this is necessary because the value of *c* is expressed in thousandths while the value of *t* is expressed in ten-thousandths of the lunation); add 7207;[1] deduct from the total the amount of equation *c* (*Table VI.*). This gives the *s*, or the index of the apparent sun; *s* + *t* gives the index of the nakshatra for use with Table VIII. (*See* § 119.)

An inscription in South India of a year corresponding to K.Y. 4330 expired, A.D. 1229-30, bears the following date—On the day of Rōhiṇī, which was a Sunday and the third tithi of the second fortnight (*krishṇa paksha*) in the solar month Tulā.[2] We have to find whether the nakshatra Rōhiṇī was current,

[1] The reason for this is fully explained in § 133, pp. 64, 65 of the *Indian Calendar*.

[2] An inscription of the Chōla King Rājarāja III (*Epig. Ind. X., p. 134, No. 182*).

i.e., whether the moon was in Rōhiṇī, during the given tithi. Work by the *Ārya Siddhānta* and by the "true" system.

The name of the lunar month not being given, we must first find what tithi was current (of any lunar month) at mean sunrise on the first civil day of the solar month Tulā.

Note, that by Table I., cols. 19, 23, 24, 25, on February 26th (57) at mean sunrise the *a*, *b*, *c* were respectively 166, 883 and 205. Now to find the interval from Mēsha saṁkrānti to Tulā saṁkrānti. Table XVIII.A gives us this, viz., 186 d. 21 h. 25 m., and Mēsha saṁkrānti having occurred (*Table I., cols.* 13, 17) on Day 83 at 22 h. 32 m., we have it that the Tulā saṁkrānti occurred on Day 270, or (*Table IX.*) September 27th, at 19 h. 57 m. By all South-Indian rules, therefore (*above* § 43, iii., iv.), the first civil day of Tulā began at sunrise on Day 271, or September 28th. This gives an interval of (271 — 57) 214 days exactly from sunrise on Chaitra śukla 1st to sunrise on September 28th, or the 1st Tulā :—

	a.	*b.*	*c.*
Chaitra śuk. 1st (*Table I.*), mean sunrise	166	883	205
214 days (*Table IV.*)	2467	766	586
At mean sunrise on 1st Tulā	2633	649	791
Equation *b*	27		
Equation *c*	119		
t =	2779 = (*Table VIII.*) śukla 9th.		

We add the *a*, *b*, *c* for the interval of 9 days from śukla 9 to kṛishṇa 3 (the given day) to the *a*, *b*, *c* of 1st Tulā :—

	a.	*b.*	*c.*
1st Tulā, as above	2633	649	791
9 days (*Table IV.*)	3048	327	25
At mean sunrise on 10th Tulā	5681	976	816
Equation *b*	120		
Equation *c*	116		
t =	5917 = (*Table VIII.*) kṛish. 3.		

At sunrise on the 10th Tulā, then, or October 7th, which was a Sunday, the given tithi was current, with *c* = 816, equation *c* 116, and tithi-index 5917.

Work for the nakshatra by the above rule.

c × 10	8160
Add constant	+ 7207
	5367
Deduct equation (*c*)	— 116
Apparent sun, or *s* =	5251
Add *t* of mean sunrise (as found)	+ 5917
Apparent moon, or nakshatra-index, *n* =	1168

By Table VIII., col. 8, we see that with index 1168 the nakshatra Rōhiṇī was current, or in other terms the moon was in Rōhiṇī, at mean sunrise. All the elements of the date are therefore correct as given.

Example 44.—*The same. To find the beginning and ending times of the nakshatra.*

Rule. Having ascertained the nakshatra-index, or *n*, as in the last example, Table VIII. gives the name of the current nakshatra, and its beginning and ending points by the three systems. The difference in mean time is obtained from Table X.

Take the case examined in the last example. It was there shown that at sunrise on the 10th Tulā, Sunday, October 7th, A.D. 1229, the nakshatra Rōhiṇī was current, with $n = 1168$.

By the equal-space system, Rōhiṇī began (*Table VIII., col.* 8) with $n = 1111$. $1168 - 1111 = 57$; and 57 (*Table X.*, "nakshatra-index") = 3 h. 44 m. It ended with $n = 1481$. $1481 - 1168 = 313$, and 313 (*Table X.*) is (19 h. 40 m. + 51 m. =) 20 h. 31 m. By this system, therefore, it began, *i.e.*, the moon entered it, at 3 h. 44 m. before, and ended, *i.e.*, the moon left it, at 20 h. 31 m. after mean sunrise on October 7th.

By the system of Garga we have for its beginning $1168 - 926 = 242$ = (*Table X.*) 13 h. 7 m. + 2 h. 45 m. = 15 h. 52 m. before, and for its ending $1481 - 1168$, or 20 h. 31 m. after, mean sunrise, the latter being the same as its ending-point according to the equal-space system.

By the *Brāhma Siddhānta* it began $1168 - 915 = 253$ = (*Table X.*) 13 h. 7 m. + 3 h. 29 m. = 16 h. 36 m. before, and for its ending $1464 - 1168 = 296$ = (*Table X.*) 13 h. 7 m. + 6 h. 18 m. = 19 h. 25 m. after, mean sunrise.

Example 45.—*The same as Example* 43. *An inscription from Northern India.* (*Ind. Ant. IX., p.* 183-84, *XVII., p.* 247, *No.* 3; *Epig. Ind. V., App.* 77, *No.* 562.) Nēwār era, saṁvat 533 expired, 13th śukla tithi (bright half) of Māgha, Sunday, the nakshatra Punarvasu. I give the full working, as this may prove helpful.

Years of the Nēwār era begin with the lunar month Kārttika, and the epoch of the era or Nēwār era 0 = A.D. 878–9. Māgha in Nēwār 533 expired is therefore (879 + 533), Māgha in A.D. 1412–13 current, or in K.Y. 4514 current (*Table II., Part III.*). We work, therefore, from the Mēsha saṁkrānti moment of K.Y. 4514 current (*Table I.*) by the *Sūrya Siddhānta*, which was in use in the north, and by the system of true months. We work also from mean sunrise on Chaitra śukla 1st as given for that year in Table I. The interval between Chaitra śukla 1st sunrise and sunrise on Māgha śukla 13 is (*Table III., col.* 3*a*) 295 days to end of Pausha and beginning of Māgha + 13 tithis, or approximately 13 days. Total, 308 days.

	d.		*w.*	*a.*	*b.*	*c.*
Chaitra śuk. 1st, mean sunrise (*Table I.*)	13 March	(73)	1	9742	193	243
Interval of 308 days (*Table IV.*)		(308)	0	4299	178	843
		(381)	1	4041	371	86
Equation *b*				241		
Equation *c*				29		
				$t = 4311$		

Day 381 = (*Table IX.*, A.D. 1412 being a leap-year) January 15th, A.D. 1413, which was a (1) Sunday. $t = 4311$ proves (*Table VIII.*) that at mean sunrise on this day the 13th śukla tithi was current. As the day was a Sunday, we find the inscription date so far correct. The tithi ended at 4333 (*Table VIII., col.* 3) and $4333 - 4311 = 22$ = (*Table X.*) 1 h. 34 m.; we therefore find that the 13th tithi ended 1 h. 34 m. after mean sunrise. Kielhorn gave the hour of its ending as 1 h. 25 m., working by a different system. (*Ind. Ant. XVII.*, 247.)

The work for the nakshatra is as follows:—

$c \times 10$		860
+ Constant		7207
		8067
— Equation *c*		— 29
	$s =$	8038
+ *t*		4311
	$n =$	2349

This ($n = 2349$) is Punarvasu by Table VIII., col. 8, by the equal-space system; though by the systems of Garga and the *Brāhma Siddhānta* the current nakshatra for sunrise on January 15th was Ārdrā. But finding Punarvasu quoted, it is clear that the calculators used the equal-space system.

EXAMPLE 46.—*To find the moon's nakshatra by Dr. Schram's method.* (*Table XXIII*).

Take the c of the moment in question as found by work. Note the value of s opposite to it in the Table. Observe the amount of difference between it and the next higher value of c. With this difference, turn to the first column of the auxiliary Table and run the eye horizontally along to the last figure of argument c as given in the headline. The figure below this has to be added to the s found. Thus: say that c is 426. Argument c in the Table, 420, gives 1376 for s. Difference between 420 and 430 is 97. In the auxiliary Table, opposite 97 and under 6, the last figure of c, is 58. $s = 1376 + 58, = 1434$. $s + t = n$, the nakshatra-index.

Take Example 43, where c was found to be 816 and t 5917. Table XXIII. gives for 810 (under "Arg. c") $s = 5190$; with difference 102 between 810 and 820. The auxiliary Table gives, — for difference of s, 102 with 6 as here the last figure of Arg. c —, 61. $5190 + 61 = 5251$. This is the same as the s found in the example; and (s) 5251 + (t) 5917 = the nakshatra-index (n) 1168.

EXAMPLE 47.—*To find the yōga current at a given moment.*

Rule. Find the t at sunrise on the given day, or at the given moment, by the previous Examples 20 to 22, also the c and equation c. From these, working as for the nakshatra, find the s, or longitude of apparent sun. Multiply s by 2 and add t. This gives (y) the yōga, by using Table VIII., cols. 11 to 13.

I take the dates examined in Examples 43, 45, and show how to find the current yōga.

(A) *Example* 43. $t = 5917$. $s = 5251$. $s \times 2 = 502$. $y = 502 + 5917 = 6419$. This is the index of the yōga, which by Table VIII. was Varīyas.

(B) *Example* 45. $t = 4311$. $s = 8038$. $s \times 2 = 6076$. $y = 6076 + 4311 = 387$. This is the yōga-index, and it shows that Prīti was current (*Table VIII., cols.* 12, 13). This is the yōga mentioned in the inscription.

The beginning and ending times of yōgas can be found from the figures given in Table VIII., col. 13, just in the same way as the beginning and ending times of tithis (*col.* 3) or of nakshatras (*cols.* 8, 9, 10); remembering that our y in these examples is the yōga-index for mean sunrise. Thus, in Example 43, y was 6419 at mean sunrise. Varīyas began at 6296. $6419 - 6296 = 123 =$ (*Table X., col.* "*Yōga Index*") 6 h. 6 m. + 1 h. 24 m. = 7 h. 30 m. It ended at 6667. $6667 - 6419 = 248 =$ 12 h. 12 m. + 2 h. 56 m. = 15 h. 8 m. Thus, Varīyas began at 7 h. 30 m. before mean sunrise (taken as 6 a.m.) on Sunday, October 7th, A.D. 1229, or, in European reckoning, at 10.30 p.m. on Saturday, October 6th; and ended 15 h. 8 m. after 6 a.m., or at 21 h. 8 m. Laṅkā time on the Sunday, or, in European reckoning, at 3.8 a.m. on Monday, October 8th.

EXAMPLE 47A.—*To find the karaṇa of a given moment.*

A karaṇa is half a tithi. The names of each will be found in cols. 4 and 5 of Table VIII. Thus, during the first tithi running from ($t =$) 0 to 333, Kiṁstughna is the karaṇa from 0 to 166½, and Bava the karaṇa from 166½ to 333.

One or two examples will suffice. In Example 20 we found that the 15th tithi of the bright half of Chaitra in K.Y. 4250 expired was current at mean sunrise on March 25th, A.D. 1149, with $t = 4691$. The karaṇa, therefore, current at that moment was Vishṭi.

In the third column of the Pañchāṅg extract published at pp. 14, 15 of the *Indian Calendar* we see that at mean sunrise on the Friday, on which the 14th tithi of the bright half of Bhādrapada was current, that tithi had only 5 gh. 18 p. to run, or (*Table XXV.*) 2 h. 7 m. So that we know that the second half of the 14th tithi was then current, and, accordingly, the karaṇa was Vaṇij, viz., the karaṇa appropriate to the second half of the 14th śukla tithi (*Table VIII., col.* 5).

JOVIAN SAṀVATSARAS.

EXAMPLE 48.—*To find which saṁvatsara began in a given solar year, and which was current at apparent Mēsha saṁkrānti of that year.*

Rule. If the given solar year is not an expired year of the Kaliyuga, it must be turned into it (*Indian Calendar Table I., or Table II. Part III.*). This done, find from Table XXVII., XXVIII., XXIX., XXX. or XXXI., col. 1, according to the authority to be used, the number of the expired K.Y. year in which began the Prabhava, No. 1, of the cycle concerned. Subtract this number from the number of the given K.Y. year, and add 1 to the remainder. With the resulting number, turn to Table XXVII.A, XXVIII.A, &c., according to the authority used, and find it in col. 1. If the number of days opposite to it in col. 3 is less than the number of days given in col. 3 of Table XXVII., XXVIII., &c., for the Prabhava, No. 1, of the cycle, then the saṁvatsara given in col. 2 of Table XXVII.A or XXVIII.A, &c., will begin in the given solar year. If not, it will begin in the preceding year, and the next saṁvatsara in the list will begin in the given year.

Wanted, the saṁvatsara which began in each of the given expired years K.Y. 3497, 3498, 3499, 3500, and the saṁvatsara current at the apparent Mēsha saṁkrānti of each of these years.

Work by the *Sūrya Siddhānta* without the bīja, *i.e.*, by Tables XXVII. and XXVII.A. By col. 1, Table XXVII., the 1 Prabhava of the cycle concerned began in K.Y. 3473 expired, 106.407 days after apparent Mēsha saṁkranti. $3497 - 3473 = 24 + 1 = 25$. Therefore, 25 Khara, whose number in col. 3 of Table XXVII.A is 101.569 days (less than 106.407), began in the course of K.Y. 3497 expired; and 24 Vikṛita was current at Mēsha saṁkrānti of that year.

$3498 - 3473 = 25 + 1 = 26$ Nandana, with 105.801 days (less than 106.407). Therefore, 26 Nandana began in the course of K.Y. 3498 expired, and 25 Khara was current at apparent Mēsha saṁkrānti of that year.

$3499 - 3473 = 26 + 1 = 27$ Vijaya, with 110.033 days (greater than 106.407). Therefore, 27 Vijaya began, not in 3499 expired, but in 3498 expired, and 28 Jaya began in 3499 expired. 26 Nandana both began and ended in 3498 expired, and was therefore expunged; and while 25 Khara was current at apparent Mēsha saṁkrānti of 3498, 27 Vijaya was current at the same moment of 3499.

$3500 - 3473 = 27 + 1 = 28$ Jaya, with 114.265 days (greater than 106.407). Therefore, 29 Manmatha began in K.Y. 3500.

[*Note.*—For the years K.Y. 3401 expired to 5001 expired, Table I. of the *Indian Calendar* supplies all the necessary information in cols. 6, 7, but only for the *Sūrya Siddhānta* without the bīja. For a result by other authorities the pairs of Tables XXVIII., &c., must be used.]

EXAMPLE 49.—*Another method of finding the same.*

Rule. Take the first of the pair of Tables devoted to the authority by which the calculation is to be made, *e.g.* Table XXVII. or XXVIII., &c. Deduct from the number of the given expired K.Y. year the number of the K.Y. year in which 1 Prabhava of the cycle began (col. 1). The remainder gives the number of the saṁvatsara current at apparent Mēsha saṁkrānti of the given year (*Table XXVII.A, XXVIII.A, &c.*) if col. 4 of Table XXVII. or XXVIII., &c., shows that there was no expunction during the cycle, or that an expunction of a later saṁvatsara occurred in it. If such were the case the next following saṁvatsara was then current.

Take the same solar years as in the last example, viz., the expired years K.Y. 3497 to 3500. No. 1 Prabhava of the cycle began, according to the *Sūrya Siddhānta* without the bīja, by which we will be guided here, in K.Y. 3473. 26 Nandana was expunged (*Table XXVII., col.* 4) in K.Y. 3498.

$3497 - 3473 = 24$. 24 Vikṛita (Table XXVII.A) was current at apparent Mēsha saṁkrānti of K.Y. 3497 expired.

3498 — 3473 = 25. 25 Khara was current at M. S. of K.Y. 3498.

3499 — 3473 = 26. But 26 Nandana was expunged. Therefore, 27 Vijaya was current at M. S. of K.Y. 3499.

3500 — 3473 = 27. But as 26 Nandana was expunged, 28 Jaya was current at M. S. of K.Y. 3500 expired.

Hence, 25 Khara began in K.Y. 3497 expired. 26 Nandana and 27 Vijaya both began in K.Y. 3498 expired. And 28 Jaya began in K.Y. 3499 expired.

EXAMPLE 50.—*To find the time of beginning and ending of a Jovian saṁvatsara according to the Sūrya Siddhānta without the bīja.*

Find from Table XXVII. the beginning-time in days and decimals of the first saṁvatsara, Prabhava, of the current cycle, *i.e.*, of the Prabhava which, in col. 2 of that Table, begins in the year next previous to the given year. Note the interval of years between that Prabhava-year and the given year, and add 1 to the number. Following the working rule given in § 137, determine which saṁvatsara began in the given year. Deduct its number of days and decimals in col. 3 of Table XXVII.A from the number of days in col. 3 of Table XXVII. (or from the number of days so given + 365.2588) of the first saṁvatsara, Prabhava, of the cycle. The remainder shows the number of days intervening between apparent Mēsha saṁkrānti of the solar year previous to the given year and the beginning-moment of the saṁvatsara in question. Find from Table I. the moment of that Mēsha saṁkrānti. Add to it the remainder last found, expressed in days, hours and minutes by help of Table XXXVI. The result shows the day, hour and minute of the beginning of the required saṁvatsara. For its end, add 361.02672 days, or 361 d. 0 h. 38 m. 29 s., to the time of beginning.

Wanted, the time of beginning and ending of the saṁvatsara, Krōdhana, stated in Table I. as being expunged in the year corresponding to K.Y. 3412 expired (A.D. 311–12).

This is the example worked out by the full and complicated *Sūrya Siddhānta* method in § 59A, p. 34, of the *Indian Calendar*. It showed that the cyclic year 59 Krōdhana began on the 20th March, A.D. 311, at 59 gh. 25.2 p., or 23 h. 46 m. 5 s. after mean sunrise, and therefore that the saṁvatsara current at apparent Mēsha saṁkrānti in that year (which corresponds to K.Y. 3412 expired), or on March 17th, was the previous saṁvatsara, 58 Raktāksha. I proceed to calculate the beginning of Krōdhana in that year by my present Tables. 3412 — 3354 (the year of No. 1 Prabhava of the cycle) + 1 = 59. Therefore, 59 Krōdhana (*see rule*) began in K.Y. 3412 expired.

	d.
(*Table XXVII.*) Prabhava of K.Y. 3354	248.99263[1]
(*Table XXVII.A*) Krōdhana	— 245.45806
	3.53457

3.53457 = (*Table XXXVI.*) 3 d. 12 h. 49 m. 47 s.. Krōdhana began at this distance of time after apparent Mēsha saṁkrānti of K.Y. 3412, which occurred according to the *Ārya Siddhānta* on March 17th, A.D. 311, at 11 h. 17 m. after mean sunrise (*Table I., cols.* 13, 17). To obtain this latter moment according to the *Sūrya Siddhānta* we have to deduct (*Table XVII.*) 20 m.; but as in this example I wish to be as accurate as possible, I calculate the difference by the Table on p.55 of the *Indian Calendar*, which gives it as 20.1 m., or 20 m. 6 s. Apparent Mēsha saṁkrānti, therefore, by the *Sūrya Siddhānta* occurred on March 17th at 10 h. 56 m. 54 s. Therefore, Krōdhana began on March 20th at (12 h. 49 m. 47 s. + 10 h. 56 m. 54 s.), 23 h. 46 m. 41 s. after mean sunrise.

The result, therefore, by my Tables differs by only 36 s.[2] from the result obtained by the full Hindū method as enjoined by the *Sūrya Siddhānta*. If, however, we add to the moment of true Mēsha

[1] I have added the actual fifth decimal figure here, though it does not appear in the Table.

[2] Compare this with the result obtained in § 158.

saṁkranti according to the *Ārya Siddhānta* the thirty seconds required for still more accurate calculation (*see* "*Hint*" *No.* 20, *p.* 79) it will be found that the difference between the result obtained by the use of my Tables and the result obtained by the full Hindū method of working amounts to 1 m. 6 s. But, at any rate, I am justified in believing that my Tables are slightly more accurate than the two put forward originally by Mr. Sh. B. Dikshit, by which the result obtained would have been 23 h. 50 m. 11 s.

Krōdhana ended (3.53457 + 361.02672) 364.56129 days after apparent Mēsha saṁkrānti, or before the apparent Mēsha saṁkrānti of the next year, which was 365.2588 days later than the former. It was therefore expunged.

[With Dr. Schram's fixture for the value of the śōdhya interval (*Text*, § 39D) the final result would be 2 m. 35 s. earlier than that obtained by my Tables. By him, therefore, Krōdhana began on March 20th at 23 h. 44 m. 36 s.; or 1 m. 29 s. earlier than the time obtained by use of the full working according to the *Sūrya Siddhānta*.]

EXAMPLE 51.—*Another example, showing how to find the sign in which Jupiter, by his mean motion, stood on a particular day, as well as the time of beginning and ending of the current saṁvatsara.*

In the *Indian Antiquary*, Vol. XXV. (1896), p. 55, No. 13, Professor Kielhorn analysed a Kollam Era date, which quotes Jupiter as having been, at a time corresponding to mean sunrise on November 11th, A.D. 1581, in the mean sign Dhanus.

I work, as did the Professor, by the *Sūrya Siddhānta* without the bīja.

The date fell in K.Y. 4682 expired (*Table I.*). The cycle began (*Table XXVII.*) with No. 1 Prabhava in K.Y. 4659. 4682 — 4659 = 23 + 1 = 24 = Vikṛita. 24 Vikṛita therefore began in K.Y. 4682.

	d.
1 Prabhava K.Y. 4659 (*Table XXVII.*)	141.5872
24 Vikṛita (*Table XXVII.A*)	97.3368
	44.2504

	d.	h.	m.	s.
44.2504 = (*Table XXXVI.*)	(44)	6	0	35
Mēsha saṁkrānti K.Y. 4682, expired (*Table I.*) .	(87)	1	51	30
Beginning-time of Vikṛita	(131)	7	52	5
Add for ending-time	(361)	0	38	29
Ending-time	(492)	8	30	34

131 = May 11th, A.D. 1581 (*Table IX.*)
492 = May 7th, A.D. 1582 (*Table IX.*)

24 Vikṛita therefore began on May 11th, A.D. 1581, at 7 h. 52 m. 5 s., and ended on May 7th, A.D. 1852, at 8 h. 30 m. 34 s., after, in each case, mean sunrise.

Hence, on the given date (11 November, 1581) 24 Vikṛita was current. Reference to the last column of Table XXXII. shows that during the currency of 24 Vikṛita mean Jupiter stood in the sign Makara. He was therefore in Makara and not in Dhanus on the given day. This corresponds with the finding of Kielhorn, who also fixes the beginning day of 24 Vikṛita and the ending day of 23 Virōdhin as May 11th, A.D. 1581.

[Nevertheless (and epigraphists must always be prepared for such cases) this result does not suffice by itself, in my opinion, to prove the date irregular. At Mēsha saṁkrānti of K.Y. 4682 the current saṁvatsara was 23 Virōdhin, for we have proved that 24 Vikṛita began in May, A.D. 1581, while the apparent Mēsha saṁkrānti of K.Y. 4682 took place in March, during the currency of Virōdhin. Hence, it is probable that in most tracts the year K.Y. 4682 would have been coupled with Virōdhin in all its

length; and it is quite possible that, this being so, Jupiter in November might have been described in almanacs as standing in Dhanus, which corresponds with Virōdhin, though he had actually passed out of it and into Makara by that time.

Testing the date by the *Sūrya Siddhānta* with the bīja, and by the *Ārya Siddhānta,* I find in each case a similar result as regards the sign in which Jupiter stood on the given day.]

EXAMPLE 52.—*A similar case. Rough calculation, but sufficient.*

Rule. To obtain an approximation, which is often sufficient, neglect all decimals in the pair of Tables used. Find the beginning of the saṁvatsara in question. Add to it 361 days for its duration, and so find its end. Common sense will show if closer calculation is desirable. Thus—

It is required to know what saṁvatsara was current on August 26th, A.D. 1296, according to the system in force in Northern India, and by the *Sūrya Siddhānta* without the bīja. The K.Y. year was 4397 expired. Table I., col. 7, shows that 35 Plava was current at apparent Mēsha saṁkrānti. The cycle began with 1 Prabhava K.Y. 4362. 4397 — 4362 = 35 + 1 = 36 Śubhakṛit. It began in K.Y. 4397, and therefore 35 Plava is correctly given as current at Mēsha saṁkrānti of that year. From col. 3 of Tables XXVII. and XXVII.A we obtain, for beginning of Plava, 315 (days for Prabhava) — 144 (days for Plava), or 171 days after Mēsha saṁkrānti of K.Y. 4396 expired, or after (*Table I., col.* 13) March 26th, A.D. 1295. This is the 85th day. 171 + 85 = 256 = (*Table IX.*) September 13th, A.D. 1295. Add 361 days and we have 617, or September 9th, A.D. 1296. We know, therefore, that Plava lasted from September 13th, 1295, to September 9th, 1296, and that it was current on August 26th, 1296. There is no need for closer calculation, or use of decimals.

EXAMPLE 53.—*To find the time of beginning of a Jovian saṁvatsara according to the Sūrya Siddhānta with the bīja.*

Rule. Work as in Example 50, but use Tables XXVIII. and XXVIII.A.

(A.) Wanted, the time of beginning of 32 Vilamba, which, as shown by Table I., col. 7, was, by the correct northern system, current at apparent Mēsha saṁkrānti of K.Y. 4869 expired, A.D. 1768-9.

The cycle began with 1 Prabhava in K.Y. 4837 expired. Vilamba began in K.Y. 4868.

(*Table XXVIII.*) Prabhava, K.Y. 4837	149.1479		
(*Table XXVIII.A*) 32 Vilamba	— 130.9473		
	18.2006		
	d.	*h.*	*m.*
18.2006 days = (*Table XXXVI.*)	18	4	49
Mēsha saṁkrānti K.Y. 4868 (*Table I., cols.* 13, 17A) .	100	4	56
	118	9	45

118 = (*Table IX.*) April 28th. Vilamba therefore began on April 28th, A.D. 1767, at 9 h. 45 m.

Prof. Kielhorn, working by his own method, stated the result as on the same day at 9 h. 45.5 m. (*Indian Antiquary,* Vol. XVIII., 1889, p. 194.)

(B.) Wanted, the time of beginning, by the same authority, of the saṁvatsara current at apparent Mēsha saṁkrānti of K.Y. 4397 expired, A.D. 1296.

Here we first have to find the proper day-figure for a Prabhava at the beginning of a cycle earlier than any entered in Table XXVIII. This is a problem we are seldom called on to solve, but it is well to show how it can be treated if necessary. First find the number of cycles elapsed between the beginning of the 1 Prabhava of the cycle containing the given year and the 1 Prabhava of K.Y. 4540, viz., the first entered in Table XXVIII. It is easy to see that in this case three cycles elapsed. We have the figure in Table XXVIII. for 1 Prabhava, K.Y. 4540, viz., 320.6033 days, and remembering (*see Text,* § 151) that each 1-Prabhava-figure advances on the last by 111.8124 days, we deduct this

amount multiplied by 3, or 335.4372 from the Table XXVIII. figure for K.Y. 4540, *i.e.*, from 320.6033, adding to the latter the solar year-length, 365.2588, to enable us to do so.

$$\begin{array}{r} 320.6033 \\ +\ 365.2588 \\ \hline 685.8621 \\ -\ 335.4372 \\ \hline 350.4249 \end{array}$$

This last is the Table XXVIII. figure for Prabhava of the third cycle before K.Y. 4540. This figure being so large, we know (*Text, Hints, No.* 19) that no expunction of a saṁvatsara took place in that cycle, and that, therefore, there were expunctions in the next two cycles. By consequence, the first of those cycles occupied 60 solar years, and the other two 59 solar years each. Total interval from K.Y. 4540 = (60 + 59 + 59) 178 solar years. 4540 — 178 = 4362. Therefore, the Prabhava of the cycle containing the given saṁvatsara began in K.Y. 4362 expired. Interval 4397 (the given year) — 4362 = 35. Therefore, 35 Plava was the saṁvatsara current at apparent Mēsha saṁkrānti of K.Y. 4397 expired. It began in K.Y. 4396 expired.

1 Prabhava of K.Y. 4362, as obtained	350.4249
35 Plava (*Table XXVIII.A*)	— 143.6196
	206.8053

	h.	m.	s.
.8053 of a day (*Table XXXVI.*) = ...	19	19	37.92

Call this 19 h. 20 m.

	d.	h.	m.	s.
Mēsha saṁk. of K.Y. 4396, expired (*Table I.*)	85	1	45	30
	+ 206	19	19	38
	291	21	5	8

The Plava in question therefore began (*Table IX.*) on (291 =) October 18th, A.D. 1295, at 21 h. 5 m. after mean sunrise.

Prof. Kielhorn (*Ind. Ant.*, Vol. XVIII., 1889, *p.* 380) gave the result as 21 h. 4 m.

EXAMPLE 54.—*The same. To find its end.*

Rule. Add to the beginning-time of the saṁvatsara as found by the last example 361.03465, or 361 d. 0 h. 49 m. 54 s., or, shortly, 361 d. 0 h. 50 m.

Wanted, the end respectively of the Vilamba and Plava saṁvatsaras whose beginnings were established as 118 d. 9 h. 45 m. and 291 d. 21 h. 24 m. in the years A.D. 1767-8 and A.D. 1295-6. (*Example* 53.)

d.	h.	m.
118	9	45
361	0	50
479	10	35

d.	h.	m.
291	21	5
361	0	50
652	21	55

479 (*Table IX.*) = (A.D. 1768 being a leap-year) April 23rd, A.D. 1768, at 10 h. 35 m. after mean sunrise, on which day Vilamba ended. And, similarly, A.D. 1296 being a leap-year, 652 = October 13th, A.D. 1296. On that day at 21 h. 55 m. after mean sunrise Plava ended.

EXAMPLE 55.—*To find the saṁvatsara current at any moment of any day by the Sūrya Siddhānta with the bīja, and the sign in which mean Jupiter stood at that moment.*

Rule. Find the time of ending of the saṁvatsara current at apparent Mēsha saṁkrānti of the given year in the manner shown in Examples 53 and 54. This done, the saṁvatsara current at the given moment is at once known. The last column of Table XXXII. shows, opposite to the name of the current saṁvatsara, the name of the sign in which, by his mean motion, Jupiter stood at the given moment.

This rule, when the proper Tables are used, of course stands good for any of the Siddhāntas.

The method of finding Jupiter's mean or apparent longitude at any moment of any day or any year is explained below. (*Examples* 61, 62.)

EXAMPLE 56.—*To find the time of beginning of a Jovian saṁvatsara according to the Ārya Siddhānta.*

Rule. Work as in Example 50, but use Tables XXIX. and XXIX.A instead of Tables XXVII. and XXVII.A.

For a working example, see the text, § 158, above.

EXAMPLE 57.—*The same. To find its end.*

Rule. Add to the time found for its beginning 361.02268 days, the length of the saṁvatsara by the *First Ārya*, and, if the total exceeds 365.25868 days, deduct this latter amount, viz., the length of the solar year, from it. 361.02268 d. = 361 d. 0 h. 32 m. 40 s. 365.25868 d. = 365 d. 6 h. 12 m. 30 s.

The beginning of 56 Dundubhi in A.D. 308 was found (§ 158) to be March 19th at 5 h. 27 m. March 19th is, in days (*Table IX.*), 79.

	d.	*h.*	*m.*
	79	5	27
+	361	0	33
	440	6	0
−	365	6	12
	74	23	48

74 (*Table IX.*) =, in A.D. 309, March 15th. On this day at 23 h. 48 m. after mean sunrise Dundubhi ended.

EXAMPLE 58.—*To find the saṁvatsara current according to the Ārya Siddhānta on any day.*

This will be settled after finding the beginning and ending of the current saṁvatsara by Examples 56, 57.

EXAMPLE 59.—*To find the beginning and ending times of a Jovian saṁvatsara according to the Original Sūrya Siddhānta.*

The process is described in the text, §§ 159 to 162 above, especially in the example at the end of § 162. Tables XXX. and XXX.A are to be used.

In § 158 of the text, we found, working according to the *Ārya Siddhānta* (*Āryabhaṭīya*), that, if that authority had been used as the basis of calculation (it was not in existence at so early a date) the solar year K.Y. 3410 expired, A.D. 309–10, would have been coupled with No. 56 Dundubhi, since the saṁvatsara so named was current at its apparent Mēsha saṁkrānti; that Dundubhi began on March 19th, A.D. 308, at 5 h. 27 m., and ended on (*see Example* 57) March 15th, A.D. 309, at 23 h. 48 m. after mean sunrise.

We now test this for the *Original Sūrya Siddhānta.* The given saṁvatsara is the one which was current at apparent Mēsha saṁkrānti of K.Y. 3410 expired. 1 Prabhava of the cycle (*Table XXX.*) began 246.8219 days after mean Mēsha saṁkrānti of K.Y. 3354 expired. 3410 − 3354 = 56, Dundubhi. Dundubhi began in K.Y. 3409 expired. We have to find the moment of mean Mēsha saṁkrānti of that year by the *Original Sūrya Siddhānta.*

		d.	h.	m.	s.
Apparent Mēsha saṁk. by *Ārya S.* (*Table I.*)		(76)	16	40	0
Add śōdhya.		(2)	3	32	30
Mean Mēsha saṁk. by *Ā. S.*		(78)	20	12	30
Deduct for diff. of (499 — 308) 191 years, by Table in Text, § 162 (10 m. + 9 m. + 6 s.)	—			19	6
Mean Mēsha saṁk. by *Orig. S. S.*	(A)	(78)	19	53	24

Again :—

		d.
(By Table XXX.) 1 Prabhava of K.Y. 3354 expired		246.8219
(By Table XXX.A) 56 Dundubhi	—	232.7619
	(B)	14.0600

	d.	h.	m.	s.
14.0600 = (Table XXXVI.)	14	1	26	24
(A) =	78	19	53	24
(A) + (B)	92	21	19	48

Hence, 56 Dundubhi began (92, by Table IX. =) on April 1st, A.D. 308, at 21 h. 20 m. after mean sunrise.

It ended 361 d. 0 h. 38 m. 28 s. later, or, on March 28th, A.D. 309, at 21 h. 58 m. after mean sunrise.

[Calculating the same by the *Sūrya Siddhānta* without the bīja, I find that the beginning of this Dundubhi was on April 1st, A.D. 308, at 21 h. 53 m. This is in close agreement with the result of calculation by the *Original Sūrya Siddhānta*, but it differs by more than twelve days from that by the *Ārya Siddhānta*.]

EXAMPLE 59A.—*To find the times of beginning and ending of a Jovian samvatsara according to the Brāhma Siddhānta or Siddhānta Śirōmaṇi.*

The process is fully explained, and an example given, in the text, § 167A.

EXAMPLE 60.—*To find in what sign mean Jupiter stood on a given day according to Kollam reckoning in North and South Malabar and Tinnevelly, the authority used being the First Ārya Siddhānta; and to find the name of the year according to the twelve-year cycle.*

Rule. Note the quoted year and month, and convert the year by the rule given in the text (§§ 174–178), or by Table II., Part III., into Kaliyuga reckoning. Ascertain, as in Example 11 above, the moment of the saṁkrānti at the beginning of the given month, and fix by the Malabar Rule IV. (*above*, § 43) which was the first civil day of the month; thence finding the European day corresponding to the given day. Find from Table I., col. 7, the Jovian saṁvatsara of the sixty-year cycle current at apparent Mēsha saṁkrānti of the solar year concerned, or obtain it by working as in Example 56 above. The last two columns of Table XXXII. give, in a horizontal line with the name and number of the sixty-year cycle saṁvatsara, the name of the equivalent twelve-year cycle saṁvatsara, as well as the sign in which mean Jupiter stood during that saṁvatsara. As a rule the whole solar year was coupled with the name of the saṁvatsara current at Mēsha saṁkrānti; but occasionally a date is reckoned by the saṁvatsara current on the given day. In this case it is necessary to find the moments of beginning and ending of the saṁvatsara current at Mēsha saṁkrānti, and this must be calculated in the manner shown in Examples 56, 57.

Wanted, according to the *Ārya Siddhānta*, (A) in N. Malabar (B) in S. Malabar and Tinnevelly, the sign in which mean Jupiter stood on the sixth day of the month Mēsha in the Kollam year 782.

Both for North and South Malabar we have to add 3926 to the given Kollam year, since the given month is Mēsha. 782 + 3926 = 4708. This is the number of the expired Kaliyuga year. From Table I. we find that by the *Ārya Siddhānta* the Mēsha saṁkrānti of that year took place on March 28th, A.D. 1607, at 17 h. 17 m. By Malabar rule the first civil day of the month Mēsha was March 29th, and the sixth day was April 3rd. Table I., col. 7, shows that the Jovian saṁvatsara current at Mēsha saṁkrānti of that year was No. 50 Anala. Or we can arrive at the same from Tables XXIX. and XXIX.A. For we see that the current cycle began in K.Y. 4659 expired, with 30 Durmukha expunged during the cycle, viz., in K.Y. 4688. K.Y. 4708 being later than 4688 we add 1 to the interval between K.Y. 4659 and 4708. 4708 — 4659 + 1 = 50. Therefore, 50 Anala was current at apparent Mēsha saṁkrānti in K.Y. 4708 (*compare Examples* 48, 49, *above*).

With 50 Anala thus determined, we turn to Table XXXII., col. 1, and in cols. 2, 3 find that the corresponding saṁvatsara of the twelve-year cycle was Bhādrapada, and that, during the whole of Anala, Jupiter stood in the sign Mīna. He was in Mīna, therefore, at the Mēsha saṁkrānti. But was he so six days later?

Turn again to Table XXIX. The Prabhava of the cycle began 123 days, roughly, after Mēsha saṁkrānti in K.Y. 4659. Then, from Table XXIX.A we find that 51 Piṅgala began 123 + 365 (the solar year-length) — 212, or 276 days after apparent Mēsha saṁkrānti of K.Y. 4708, and that was the day of the ending of 50 Anala; so that that saṁvatsara was certainly current on the given day, which was only six days after Mēsha saṁkrānti.

On the given day, therefore, 50 Anala was current. It was called also Bhādrapada, and Jupiter stood in Mīna by both North and South Malabar and Tinnevelly reckoning.

This is the same result as found by Prof. Kielhorn, *Indian Antiq.*, Vol. XXV., 1896, p. 174, No. 16.

The Mean and True Longitude of Jupiter.

Example 61.—*To find the mean place, or mean longitude, of Jupiter and of the Sun at any given time by the Sūrya Siddhānta, the Sūrya Siddhānta with the bīja, or the Ārya Siddhānta; as well as the nakshatra in which each stood.*

First find the moment of apparent Mēsha saṁkrānti of the year concerned by whichever Siddhānta it is decided to use, from Table I., or, if the information is not to be found therein, then in the manner shown in Examples 1 or 3 above. Add to the apparent Mēsha saṁkrānti time the time interval of the śōdhya correction (*see foot of Table XXXIV., or Table XXXVII., col.* 7) for the Siddhānta used. This gives the moment of mean Mēsha saṁkrānti. Note the number of the *expired* year of the Kaliyuga corresponding to the given year, *i.e.*, the year next prior to the current year as given in Table I. Take down, according to the Siddhānta selected for use, the figures for Jupiter's mean longitude given in Table XXXIII., for the number of years expired since the epoch of the Kaliyuga (*i.e.*, the number of the expired year). This gives the mean place of Jupiter at the moment of mean Mēsha saṁkrānti of the given year. Calculate the interval of days, hours and minutes from that mean Mēsha saṁkrānti to the given moment, and find Jupiter's increase in mean longitude since the moment of mean Mēsha saṁkrānti by Table XXXIV. Adding this increase to his mean longitude at mean Mēsha saṁkrānti, his mean longitude at the given moment is found.

Rule.

The sun's mean longitude is obtained by Table XXXIV. from the value given for the interval from mean Mēsha saṁkrānti to the given moment; his mean longitude at mean Mēsha saṁkrānti being always 0°.

I select, for work, the example given at p. 156 of the *Indian Calendar*, as it enables a comparison to be made between the result there found and the result arrived at from my present Tables.

The required information is the mean longitude or mean place of Jupiter at mean sunrise on a date corresponding to March 12th, A.D. 1215. We see from Table I. that this falls in K.Y. 4316 current, or 4315 expired. By the *Sūrya Siddhānta*, true Mēsha saṁkrānti of that year occurred (*Table* I., *cols.* 13, 17*a*) on March 25th (A.D. 1214) at 2 h. 43 m. The śōdhya being by that Siddhānta 2 d. 4 h. 6 m., we find that mean Mēsha saṁkrānti occurred on March 27th (A.D. 1214) at 6 h. 49 m. By the *Ārya Siddhānta* true Mēsha saṁkrānti = March 25th at 1 h. 25 m., and, the śōdhya being 2 d. 3 h. 32 m, mean Mēsha saṁkrānti = March 27th at 4 h. 57 m. The interval of time from mean Mēsha saṁkrānti to the given moment (March 12th, A.D. 1215, 0 h. Laṅkā time or mean sunrise) is by the *Sūrya Siddhānta* 350 days less 6 h. 49 m. or 349 d. 17 h. 11 m., and by the *Ārya Siddhānta* 350 days less 4 h. 57 m., or 349 d. 19 h. 3 m. We proceed to calculate the interval since mean Mēsha saṁkrānti of K.Y. 1 current by both Siddhāntas. (Remember, that there are 30° to one sign, and twelve signs.)

	Jupiter (by Sūrya S.)				*Jupiter (by Ārya S.)*				*Sun (by Sūrya S.)*				*Sun (by Ārya S.)*			
	s.	°	′	″	s.	°	′	″	s.	°	′	″	s.	°	′	″
4000 years	2	26	40	0	2	28	0	0	..	..	..	..	..	..	..	..
300 ,,	3	15	30	0	3	15	36	0	..	..	..	..	..	..	..	..
10 ,,	10	3	31	0	10	3	31	12	..	..	..	..	..	..	..	..
5 ,,	5	1	45	30	5	1	45	36	..	..	..	..	..	..	..	..
300 days	0	24	55	44	0	24	55	44	9	25	40	51	9	25	40	51
40 ,,	0	3	19	26	0	3	19	26	1	9	25	27	1	9	25	27
9 ,,	0	0	44	52	0	0	44	52	0	8	52	14	0	8	52	14
10 hours	0	0	2	5	0	0	2	5	0	0	24	38	0	0	24	38
7 ,,	0	0	1	27	..	..	..	..	0	0	17	15	..	..	..	..
9 ,,	..	..	..	..	0	0	1	52	..	..	..	..	0	0	22	11
11 minutes	0	0	0	2	..	..	..	..	0	0	0	27	..	..	..	..
3 ,,	..	..	..	..	0	0	0	1	..	..	..	..	0	0	0	7
	10	16	30	6	10	17	56	48	11	14	40	52	11	14	45	28

At mean sunrise, therefore, on the given day, the mean longitude of Jupiter was, by the *Sūrya Siddhānta*, $10^s\ 16^\circ\ 30'\ 6''$ and of the sun $11^s\ 14^\circ\ 40'\ 52''$, and by the *Ārya Siddhānta* that of Jupiter was $10^s\ 17^\circ\ 56'\ 48''$ and of the sun $11^s\ 14^\circ\ 45'\ 28''$.

This differs slightly from the figures given, by the *Ārya Siddhānta*, on p. 157 of the *Indian Calendar*, because in that instance we did not take account of the odd hours and minutes. Strictly speaking, the result there given, viz., for Jupiter $10^s\ 17^\circ\ 57'\ 49''$ and for the sun $11^s\ 14^\circ\ 57'\ 39''$, should have been stated as being the result for 4 h. 57 m. after mean sunrise on the given day. Adding to our present figures the values for Jupiter's and the sun's mean motion for 4 h. 57 m., it will be found that there is *exact coincidence.*[1]

[1] I have also worked out by my Tables the example given by Prof. Kielhorn in *Ind. Ant.*, XVIII., p. 233, in which worked by Warren's Tables, the mean longitude of Jupiter at mean sunrise on October 18th, A.D. 475, was found to be 195° 5′. Using my new Tables in the present volume, and the *Sūrya Siddhānta* (which, though it does not apply to the year in question, was evidently the authority selected by Kielhorn), I obtain for the same moment 195° 5′ 16″.

The result is that by both Siddhāntas Jupiter was in the 11th sign Kumbha, and this corresponds with the data of the inscription under examination.

If we desire to learn in which nakshatra mean Jupiter or the mean sun stood at the given moment, we turn to Table XXII. Jupiter's mean longitude by the *Sūrya Siddhānta* having been determined as 316° 30′ 6″ and the sun's 344° 40′ 52″, and by the *Ārya Siddhānta* Jupiter's longitude being 317° 56′ 48″ and the sun's 344° 45′ 28″, we find that by the equal-space system of nakshatras and by both Siddhāntas Jupiter was in 24 Śatabhishaj at the given moment, while by the Garga system and the system of the *Brāhma Siddhānta* he stood in Pūrva Bhadrapadā. By all systems the sun by both Siddhāntas was in Uttarā Bhadrapadā.

I have not thought it necessary in this case to work out the result by the *Sūrya Siddhānta* with the bīja, because it was not in use at the time in question. Calculation by it is, *mutatis mutandis*, precisely the same.

EXAMPLE 62.—*To find the true, or apparent, longitude of Jupiter at any given time, and his corresponding nakshatra.*

Rule. The rule is clearly given in § 184 above, and as it is rather long I will not attempt to repeat it. One clear example is also there given, but I think it well to give another.

Professor Kielhorn calculated the true place of Jupiter at mean sunrise on November 11th, A.D. 1581, with reference to an inscription of the Kollam era in South India, as, according to the *Sūrya Siddhānta* (without the bīja), $9^s\ 1°\ 47'$, or 271° 47′. (*Ind. Ant.*, Vol. XXV., 1896, *p.* 174, *No.* 13.) I proceed to work the date according to present rule, by the *Sūrya Siddhānta*.

The date corresponds to a day in K.Y. 4682 expired, or 4683 current.

	w.	*h.*	*m.*
True Mēsha saṁk: of that year (*Table I.*)	March 28 (87)	1	51
Sūrya Siddhānta śōdhya	2 (2)	4	6
Mean Mēsha saṁk:	March 30 (89)	5	57

Interval from mean Mēsha Saṁkrānti, K.Y. 1, to November 11th, A.D. 1581 (day 315 by Table IX.) = 4682 years, 226 days (315 — 89).

	Jupiter. s.	°	′	″		Sun. s.	°	′	″
(*Table XXXIII.*) 4000 years	2	26	40	0	...		—		
600 „	7	1	0	0	...		—		
80 „	8	28	8	0	...		—		
2 „	2	0	42	12	...		—		
(*Table XXXIV.*) 200 days	0	16	37	9	...	6	17	7	14
20 „	0	1	39	43	...	0	19	42	43
6 „	0	0	29	55	...	0	5	54	49
Mean place of Jupiter, Nov. 11th, A.D. 1581, at 5 h. 57 m. after mean sunrise . .	9	15	16	59	...	7	12	44	46
His mean motion for 5 h. 57 m. (*Table XXXIV.*)	—		1	13	...	—		14	39
His mean place at mean sunrise	9	15	15	46	...	7	12	30	7
	−7	12	30	7					
V =	2	2	45	39					

This is, roughly, 63°. Parallax for 63° = (*Table XXXV.*) 9° 14′. Half this is 4° 37′; to be deducted.

		s.	°	′	″
Mean longitude of Jupiter		9	15	15	46
	—		4	37	
		9	10	38	46
Less longitude of aphelion by *Sūrya Siddh.* (*foot of Table XXXV.*)	—	5	21		
Anomaly, W, =		3	19	38	46

This is, roughly, 110°. Equation of centre for 110° (*Table XXXV.*), 4° 52′.

		s.	°	′	″				s.	°	′	″	
Mean longitude of Jupiter		9	15	15	46		V		2	2	45	39	
	—		4	52				—		4	52		
		9	10	23	46	= helioc. longitude of Jupiter, X.			1	27	53	39	= Y.

This, roughly, is Y = 58°. Parallax for 58° = (*Table XXXV.*) 8° 41′; to be deducted from X.

	s.	°	′	″	
	9	10	23	46	
—		8	41		
	9	1	42	46	= Z,

or Jupiter's apparent longitude, as required. Excluding seconds, therefore, we find the apparent longitude of Jupiter at mean sunrise on November 11th, A.D. 1581, to be 9^s 1° 43′.

Kielhorn made it 9^s 1° 47′, a difference of 4′. This is unimportant. And the difference is reduced to 3′ if we suppose, as is highly probable, that Kielhorn, in making his calculation, took no account of the 5 h. 57 m. of the date, which in mine I have been careful to include.

By Table XXII. we find that, Jupiter's longitude being 271° 43′, he stood in the sign Makara, which began at 270°; and in the nakshatra Uttarā Ashāḍhā, by all the three systems.

Calculation can be made in this way for any of the Siddhāntas noted in Table XXXIII.

The Lagna.

Example 63.—*To find the time of any day when a particular sign of the zodiac becomes or remains lagna, i.e., rising on the eastern horizon.*

Kielhorn's definition of the lagna is worth quoting. The lagna "denotes the rising on the horizon of a sign of the zodiac and gives us the time of day when the action to which the date refers was performed." (*Indian Antiq.* XXV., 1896, *p.* 291.) (*See also* §§ 193–198 *above.*) This definition refers to the more common use of the word in epigraphic records, and in this work we do not need to notice any other of its meanings.

We ignore differences due to the angle which the ecliptic makes with the equator, or due to the fact that mean time and true time are not the same, or to the fact that the times of rising of the true sun vary with the latitude of the place; and we work only for a first approximation.

Rule. Find by the rules given above (*Examples* 20 *to* 23) the "*c*" at sunrise on the given day, or at the given moment of the day, as required, and, by Table VII. the value of equation *c*. (i.) From the formula $s = (c \times 10) + 7207 -$ equation *c*, find the value of *s*, which gives the true longitude of the sun. (ii.) Note, by Table XXII., the longitudinal distance in degrees of the given lagna. Converting *s* into degrees, minutes and seconds, find the distance between the sun at mean sunrise and the lagna. (iii.) Convert this distance into time at the rate of four minutes of time to one degree, and four seconds

of time to one minute of arc. The result is approximately the time after mean sunrise when the given lagna or rising occurred.

We require to work out the case of a lagna quoted in a South-Indian inscription of the Pāṇḍyan dynasty, and calculated by Kielhorn. (*See Epig. Ind. VI.*, 304, *No.* 6.) The year, month and day correspond to March 13th, A.D. 1223; being given as "on the auspicious occasion of the Ṛishabha (*lagna*) on the day of Pushya, . . . the ninth tithi of the first fortnight of the (solar) month of Mīna." Prof. Kielhorn found that on that day the sign Ṛishabha, or Vṛishabha, was lagna from 2 h. 28 m. to about 4 h. 28 m. after mean sunrise; so that the action referred to in the record took place between about 8.28 a.m. and 10.28 a.m. on the day in question. We proceed to verify this. The record being one belonging to the Tamil country we work by the *Ārya Siddhānta*.

We learn from Table I. that in A.D. 1223 Mēsha saṁkrānti occurred on March 25th at 9 h. 17 m. March 13th was 12 days earlier; and on March 4th (*col.* 19) we have the value of *c*, viz., 221, given in col. 25. We know, therefore, that on March 13th the month Mīna was current. [It[1] belonged to the previous year, whose Mēsha saṁkrānti occurred on March 25th (84) at 3 h. 5 m. Adding to this the interval to the Mīna saṁkrānti (*Table III. or XVIII.A*), viz., 334 d. 22 h. 5 m., we find that the latter took place on Feb. 23, A.D. 1223 (*Table IX.*) at 1 h. 10 m.; and by rule the first civil day of Mīna was the same. Therefore, March 13th was Mīna 19.]

Now to find the value of *c* at mean sunrise on March 13th. From cols. 19–25 of Table I., from Table IX. and from Table IV. we have the following :—

	d.	*w.*	*a.*	*b.*	*c.*
At mean sunrise on March 4th, 1223	(63)	0	9916	549	221
Interval to March 13th 9 days .	(9)	2	3048	327	25
At mean sunrise, March 13th, 1223	(72)	2	2964	876	246
Equation *b*			42		
Equation *c*			0		
			$t = 3006$		

$c = 246$. Equation *c* (*Table VII.*) $= 0$. Now use the formula $s = (c \times 10) + 7207 -$ equation *c*; and we find *s*, or the true longitude of the sun at mean sunrise on March 13th, $= 9667 =$ (*Table VIII.B*) $345° \, 36' + 2° \, 24'$, or 348°. [And, if we choose to note it, we find that $s + t = n = 2673$, proving the nakshatra to have been, as stated in the given date, Pushya, by Table VIII.] The first point of the solar sign Vṛishabha is (*Table XXII.*) at $(360° + 30°)$ 390°. $390° - 348° = 42°$. So, at mean sunrise on March 13th the distance between the true sun and the first point of Vṛishabha was 42°, and this, in mean time, gives $(42 \times 4 =)$ 2 h. 48 m. The last point of Vṛishabha was $(360° + 60° =)$ 420°, and this $- 348° = 72°$, or in time $(72 \times 4 =)$ 4 h. 48 m. Therefore, Vṛishabha was lagna during the two hours between 2 h. 48 m. and 4 h. 48 m. after mean sunrise on March 13th, A.D. 1223.

This is precisely the result arrived at by Kielhorn, and we know, therefore, that he considered it sufficient to work approximately for a result in the same way as we have done.

[1] The process in brackets is not really necessary for present purposes, but it might have been so if the inscription had quoted the exact serial day of Mīna corresponding to the 9th śukla lunar tithi; and I have therefore included the calculation as a guide in other cases. And so with the nakshatra.

TABLES.

TABLE XVII.

For conversion of the moment of the Mēsha Saṁkrānti as calculated by the First Ārya Siddhānta into the same moment according to the Present Sūrya Siddhānta. (Corr: I of Text.)[1]

For the reverse process, *Sūrya* to *Ārya*, the figures to be used with signs reversed.[2]

Years A.D.	Difference in Mins.	a.	b.	c.
	—			
300–308	21	5	1	0
309–317	20	5	1	0
318–327	19	4	0	0
328–336	18	4	0	0
337–345	17	4	0	0
346–354	16	4	0	0
355–363	15	4	0	0
364–372	14	3	0	0
373–381	13	3	0	0
382–391	12	3	0	0
392–400	11	3	0	0
401–409	10	2	0	0
410–418	9	2	0	0
419–427	8	2	0	0
428–436	7	2	0	0
437–445	6	1	0	0
446–455	5	1	0	0
456–464	4	1	0	0
465–473	3	1	0	0
474–482	2	0	0	0
483–491	1	0	0	0
492–500	0	0	0	0
	+			
501–509	1	0	0	0
510–519	2	0	0	0
520–528	3	1	0	0
529–537	4	1	0	0
538–546	5	1	0	0
547–555	6	1	0	0
556–564	7	2	0	0
565–573	8	2	0	0
574–583	9	2	0	0
584–592	10	2	0	0
593–601	11	3	0	0
602–610	12	3	0	0
611–619	13	3	0	0
620–628	14	3	0	0
629–638	15	4	0	0
639–647	16	4	0	0
648–656	17	4	0	0
657–665	18	4	0	0
666–674	19	4	0	0
675–683	20	5	1	0
684–692	21	5	1	0
693–702	22	5	1	0

Years A.D.	Difference in Mins.	a.	b.	c.
	+			
703–711	23	5	1	0
712–720	24	6	1	0
721–729	25	6	1	0
730–738	26	6	1	0
739–747	27	6	1	0
748–756	28	7	1	0
757–766	29	7	1	0
767–775	30	7	1	0
776–784	31	7	1	0
785–793	32	8	1	0
794–802	33	8	1	0
803–811	34	8	1	0
812–820	35	8	1	0
821–830	36	8	1	0
831–839	37	9	1	0
840–848	38	9	1	0
849–857	39	9	1	0
858–866	40	9	1	0
867–875	41	10	1	0
876–884	42	10	1	0
885–894	43	10	1	0
895–903	44	10	1	0
904–912	45	11	1	0
913–921	46	11	1	0
922–930	47	11	1	0
931–939	48	11	1	0
940–948	49	12	1	0
949–958	50	12	1	0
959–967	51	12	1	0
968–976	52	12	1	0
977–985	53	12	1	0
986–994	54	13	1	0
995–1003	55	13	1	0
1004–1013	56	13	1	0
1014–1022	57	13	1	0
1023–1031	58	14	1	0
1032–1040	59	14	1	0
1041–1049	60	14	2	0
1050–1058	61	14	2	0
1059–1067	62	14	2	0
1068–1077	63	15	2	0
1078–1086	64	15	2	0
1087–1095	65	15	2	0
1096–1104	66	15	2	0
1105–1110	67	16	2	0

Years A.D.	Difference in Mins.	a.	b.	c.
	+			
1111–1118	68	16	2	0
1119–1128	69	16	2	0
1129–1136	70	16	2	0
1137–1146	71	17	2	0
1147–1156	72	17	2	0
1157–1164	73	17	2	0
1165–1174	74	17	2	0
1175–1182	75	18	2	0
1183–1192	76	18	2	0
1193–1200	77	18	2	0
1201–1210	78	18	2	0
1211–1220	79	18	2	0
1221–1228	80	19	3	0
1229–1238	81	19	3	0
1239–1246	82	19	3	0
1247–1258	83	19	3	0
1259–1264	84	20	3	0
1265–1274	85	20	3	0
1275–1284	86	20	3	0
1285–1292	87	20	3	0
1293–1302	88	21	3	0
1303–1310	89	21	3	0
1311–1320	90	21	3	0
1321–1328	91	21	3	0
1329–1338	92	22	3	0
1339–1346	93	22	3	0
1347–1356	94	22	3	0
1357–1366	95	22	3	0
1367–1374	96	22	3	0
1375–1384	97	23	3	0
1385–1392	98	23	3	0
1393–1402	99	23	3	0
1403–1410	100	23	3	0
1411–1420	101	24	3	0
1421–1430	102	24	3	0
1431–1438	103	24	3	0
1439–1448	104	24	3	0
1449–1456	105	25	3	0
1457–1466	106	25	3	0
1467–1474	107	25	3	0
1475–1484	108	25	3	0
1485–1494	109	26	3	0
1495–1502	110	26	3	0
1503–1512	111	26	3	0
1513–1520	112	26	3	0

Years A.D.	Difference in Mins.	a.	b.	c.
	+			
1521–1530	113	26	3	0
1531–1538	114	27	3	0
1539–1548	115	27	3	0
1549–1558	116	27	3	0
1559–1566	117	27	3	0
1567–1576	118	28	3	0
1577–1584	119	28	3	0
1585–1594	120	28	4	0
1595–1602	121	28	4	0
1603–1612	122	28	4	0
1613–1622	123	29	4	0
1623–1630	124	29	4	0
1631–1640	125	29	4	0
1641–1648	126	29	4	0
1649–1658	127	30	4	0
1659–1668	128	30	4	0
1669–1676	129	30	4	0
1677–1686	130	30	4	0
1687–1694	131	31	4	0
1695–1704	132	31	4	0
1705–1714	133	31	4	0
1715–1722	134	31	4	0
1723–1732	135	32	4	0
1733–1742	136	32	4	0
1743–1750	137	32	4	0
1751–1758	138	32	4	0
1759–1768	139	32	4	0
1769–1776	140	33	4	0
1777–1786	141	33	4	0
1787–1796	142	33	4	0
1797–1808	143	33	4	0
1809–1814	144	34	4	0
1815–1824	145	34	4	0
1825–1832	146	34	4	0
1833–1842	147	34	4	0
1843–1850	148	35	4	0
1851–1860	149	35	4	0
1861–1872	150	35	4	0
1873–1878	151	35	4	0
1879–1888	152	36	4	0
1889–1896	153	36	4	0
1897–1900	154	36	4	0

[1] Owing to the fractions involved in these differences the sum of the minutes is often one more or less than the actual amount, but this does not affect the value of *a*, *b*, *c* as given. For "Correction I" see Text, § 46, &c.

[2] The + sign shows that the Mēsha Saṁkrānti according to the *Sūrya* took place after, the — sign that it took place before, that according to the *Ārya Siddhānta*.

TABLE XVIII.A.

DURATION AND COLLECTIVE DURATION OF true, or apparent, solar months, WITH INCREASE OF *a*, *b*, *c* AT EACH SAṀKRĀNTI.

By the Ārya Siddhānta.

Luni-Solar month. (*Ending after the second of the two saṁkrāntis with which it is connected.*)	Solar saṁkrānti.	Collective duration in days and collective increase of *a*, *b*, *c*, from Mēsha saṁkrānti to each saṁkrānti.									Length of each month between saṁkrāntis and increase of *a*, *b*, *c*, between each saṁkrānti.									
		D.	Gh.	P.	D.	H.	M.	*a.*	*b.*	*c.*	D.	Gh.	P.	D.	H.	M.	S.	*a.*	*b.*	*c.*
1	2	3			4			5			6			7				8		
1. Chaitra....	Mīna (*of previous year*)																			
2. Vaiśākha ..	Mēsha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Jyēshṭha ..	Vṛishabha ..	30 (2)	55	30	30 (2)	22	12	472	122	85	30 (2)	55	30	30 (2)	22	12	0	472	122	85
4. Āshāḍha ..	Mithuna	62 (6)	19	34	62 (6)	7	49	1106	262	171	31 (3)	24	4	31 (3)	9	37	36	634	140	86
5. Śrāvaṇa ..	Karka	93 (2)	56	0	93 (2)	22	24	1809	409	258	31 (3)	36	26	31 (3)	14	34	24	703	147	87
6. Bhādrapada	Siṁha	125 (6)	24	4	125 (6)	9	38	2465	551	343	31 (3)	28	4	31 (3)	11	13	36	656	142	85
7. Āśvina ...	Kanyā	156 (2)	26	9	156 (2)	10	28	2975	677	428	31 (3)	2	5	31 (3)	0	50	0	510	126	85
8. Kārttika ..	Tulā	186 (4)	53	33	186 (4)	21	25	3288	783	511	30 (2)	27	24	30 (2)	10	57	36	313	106	83
9. Mārgaśīrsha	Vṛiśchika ...	216 (6)	47	45	216 (6)	19	6	3413	868	593	29 (1)	54	12	29 (1)	21	40	48	125	85	82
10. Pausha ...	Dhanus	246 (1)	18	16	246 (1)	7	18	3406	939	674	29 (1)	30	31	29 (1)	12	12	24	9993	71	81
11. Māgha	Makara	275 (2)	39	18	275 (2)	15	43	3346	4	755	29 (1)	21	2	29 (1)	8	24	48	9940	65	81
12. Phālguna .	Kumbha ...	305 (4)	6	42	305 (4)	2	41	3321	73	835	29 (1)	27	24	29 (1)	10	57	36	9975	69	80
	Mīna	334 (5)	55	12	334 (5)	22	5	3414	154	917	29 (1)	48	30	29 (1)	19	24	0	93	81	82
1. Chaitra....	Mēsha ...... (*of following year*)	365 (1)	15	31	365 (1)	6	12	3689	255	0	30 (2)	20	19¼	30 (2)	8	7	42	275	101	83
											365	15	31¼	365		6	12 30			

TABLE XVIII.B.

DURATION AND COLLECTIVE DURATION OF true, or apparent, solar months, WITH INCREASE OF *a*, *b*, *c* AT EACH SAṀKRĀNTI.

By the Sūrya Siddhānta.

Luni-Solar month. (*Ending after the second of the two saṁkrāntis with which it is connected.*)	Solar saṁkrānti.	Collective duration in days and collective increase of *a*, *b*, *c*, from Mēsha saṁkrānti to each saṁkrānti.									Length of each month between saṁkrāntis and increase of *a*, *b*, *c*, between each saṁkrānti.									
		D.	Gh.	P.	D.	H.	M.	*a.*	*b.*	*c.*	D.	Gh.	P.	D.	H.	M.	S.	*a.*	*b.*	*c.*
1	2	3			4			5			6			7				8		
1. Chaitra....	Mīna (*of previous year*)																			
2. Vaiśākha ..	Mēsha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Jyēshṭha ..	Vṛishabha ..	30 (2)	56	7	30 (2)	22	27	475	123	85	30 (2)	56	7	30 (2)	22	26	48	475	123	85
4. Āshāḍha ..	Mithuna	62 (6)	21	20	62 (6)	8	32	1116	263	171	31 (3)	25	13	31 (3)	10	5	12	641	140	86
5. Śrāvaṇa ..	Karka	94 (3)	0	1	94 (3)	0	0	1831	411	257	31 (3)	38	41	31 (3)	15	28	24	717	149	86
6. Bhādrapada	Siṁha	125 (6)	28	32	125 (6)	11	25	2490	554	343	31 (3)	28	31	31 (3)	11	24	24	659	143	86
7. Āśvina ...	Kanyā ...	156 (2)	29	39	156 (2)	11	52	2994	679	428	31 (3)	1	7	31 (3)	0	26	48	504	126	85
8. Kārttika ..	Tulā	186 (4)	56	8	186 (4)	22	27	3302	784	512	30 (2)	26	29	30 (2)	10	35	36	308	105	84
9. Mārgaśīrsha	Vṛiśchika ...	216 (6)	49	44	216 (6)	19	54	3425	869	593	29 (1)	53	36	29 (1)	21	26	24	122	85	81
10. Pausha ...	Dhanus	246 (1)	19	9	246 (1)	7	40	3411	940	674	29 (1)	29	25	29 (1)	11	46	0	9986	70	81
11. Māgha	Makara	275 (2)	38	13	275 (2)	15	17	3340	3	755	29 (1)	19	4	29 (1)	7	37	36	9928	64	81
12. Phālguna .	Kumbha ...	305 (4)	5	6	305 (4)	2	2	3311	72	835	29 (1)	26	53	29 (1)	10	45	12	9972	68	80
	Mīna	334 (5)	54	19	334 (5)	21	44	3409	154	916	29 (1)	49	13	29 (1)	19	41	12	98	82	81
1. Chaitra....	Mēsha ...... (*of following year*)	365 (1)	15	32	365 (1)	6	13	3689	255	0	30 (2)	21	12.52	30 (2)	8	29	0.56	279	102	84
											365 (1), 15, 31.52			365 (1), 6, 12,36.56						

TABLE XVIII.C.

TIME AND *a*, *b*, *c* DIFFERENCE BETWEEN THE ĀRYA AND SŪRYA SIDDHĀNTAS IN THE COLLECTIVE DURATION OF ALL SUBSEQUENT SAṀKRĀNTIS FROM TRUE MĒSHA SAṀKRĀNTI. (Corr. II. of Text.)[1]

Luni-solar month. (*Ending after the second of the two saṁkrāntis with which it is connected.*)	Solar saṁkrānti.	Time and *a*, *b*, *c*, difference. [To convert *Ārya Siddhānta* results to *Sūrya Siddhānta* results apply the correction as given. To convert *Sūrya* to *Ārya* apply the correction with signs reversed.] Gh. P.	H. M.	*a*. *b*. *c*.	NOTES.
1	2	3			4
1. Chaitra	Mīna (*of previous year*)				
	Mēsha	0 0	0 0	0 0 0	When this Table (col. 3, *a*, *b*, *c*) is used with cols. 9, 11 of Table I. of the *Indian Calendar* (which gives the *t*, or moments of saṁkrāntis connected with intercalated and suppressed lunar months) only the value of *a* can be applied to the given lunation parts, *t*; and therefore the result can only be approximate. But the most extreme divergence from the correct result can only be (*a* =) + 3 or — 3, total 6, in the case of the Karka, Siṁha, and Kanyā saṁkrāntis; (*a* =) + 2 or — 2, total 4, in the case of the Tulā saṁkrānti; and (*a* =) + 1 or — 1, total 2, in the case of the Mithuna, Vṛiśchika, Dhanus, Makara, Kumbha, and Mīna saṁkrāntis.
2. Vaiśākha					
	Vṛishabha	+ 0 37	+ 0 15	+ 4 0 0	
3. Jyēshṭha					
	Mithuna	+ 1 46	+ 0 43	+10 1 0	
4. Āshāḍha					
	Karka	+ 4 1	+ 1 36	+22 3 0	
5. Śrāvaṇa					
	Siṁha	+ 4 28	+ 1 47	+25 3 0	
6. Bhādrapada					
	Kanyā	+ 3 30	+ 1 24	+20 3 0	
7. Āśvina					
	Tulā	+ 2 35	+ 1 2	+14 2 0	
8. Kārttika					
	Vriśchika	+ 1 59	+ 0 48	+11 1 0	
9. Mārgaśīrsha					
	Dhanus	+ 0 53	+ 0 22	+ 5 1 0	
10. Pausha					
	Makara	— 1 5	— 0 26	— 6 1 0	
11. Māgha					
	Kumbha	— 1 36	— 0 39	— 9 1 0	
12. Phālguna					
	Mīna	— 1 53	— 0 21	— 5 1 0	
1. Chaitra					
	Mēsha (*of following year*)	— 0 1	— 0 1	0 0 0	

[1] For "Correction II." of Text, see §§ 55, 56.

TABLE XIX.A.

COLLECTIVE DURATION OF mean solar months, AND THE INCREASE OF *a* AT EACH SAMKRĀNTI.
By the Ārya Siddhānta.

Luni-solar month. (*Ending after the second of the two saṁkrāntis with which it is connected.*)	Solar sakṁrānti.	Collective duration in days from mean Mēsha saṁkrānti to each mean saṁkrānti, and corresponding collective increase of *a*.									Increase of *a* between each mean saṁkrānti.	NOTES.
		D.	Gh.	P.	Vip.	D.	H.	M.	S.	*a*.	*a*.	
1	2	3				4				5	6	7
1. Chaitra	Mīna (*of previous year*)											(i.) The figures in brackets give the week-days.
2. Vaiśākha	Mēsha	0	0	0	0	0	0	0	0	0	0	(ii.) The increase of *a* is actually 307.4165.
3. Jyēshṭha	Vrishabha	30 (2)	26	17	36¼	30 (2)	10	31	2½	307	307	(iii.) Mean Mēsha saṁkrānti is True Mēsha saṁkrānti + śōdhya, which, by the *Ārya Siddhānta*, is 2 d. 8 gh. 51 p. 15 vip. or 2 d. 3 h. 32 m. 30 s. The increase of *a* for this śōdhya interval is 727.
4. Āshāḍha	Mithuna	60 (4)	52	35	12½	60 (4)	21	2	5	614	307	
5. Śrāvaṇa	Karka	91 (0)	18	52	48¾	91 (0)	7	33	7½	923	309	
6. Bhādrapada	Simha	121 (2)	45	10	25	121 (2)	18	4	10	1229	306	
7. Āśvina	Kanyā	152 (5)	11	28	1¼	152 (5)	4	35	12½	1536	307	
8. Kārttika	Tulā	182 (0)	37	45	37½	182 (0)	15	6	15	1844	308	
9. Mārgaśīrsha	Vriśchika	213 (3)	4	3	13¾	213 (3)	1	37	17½	2152	306	
10. Pausha	Dhanus	243 (5)	30	20	50	243 (5)	12	8	20	2459	307	
11. Māgha	Makara	273 (0)	56	38	26¼	273 (0)	22	39	22½	2766	307	
12. Phālguna	Kumbha	304 (3)	22	56	2½	304 (3)	9	10	25	3073	307	
	Mīna	334 (5)	49	13	38¾	334 (5)	19	41	27½	3381	308	
1. Chaitra	Mēsha (*of following year*)	365 (1)	15	31	15	365 (1)	6	12	30	3689	308	

TABLE XIX.B.

COLLECTIVE DURATION OF mean solar months, AND THE INCREASE OF *a* AT EACH SAMKRĀNTI.
By the Sūrya Siddhānta.

Luni-solar month. (*Ending after the second of the two saṁkrāntis with which it is connected.*)	Solar saṁkrānti.	Collective duration in days from mean Mēsha saṁkrānti to each mean saṁkrānti, and corresponding collective increase of *a*.									Increase of *a* between each mean saṁkrānti.	NOTES.
		D.	Gh.	P.	Vip.	D.	H.	M.	S.	*a*.	*a*.	
1	2	3				4				5	6	7
1. Chaitra	Mīna (*of previous year*)											
2. Vaiśākha	Mēsha	0	0	0	0	0	0	0	0	0	0	The śōdhya by the *Sūrya Siddhānta* is 2 d. 10 gh. 14 p. 30 vip., or 2 d. 4 h. 5 m. 48 s. The increase of *a* for this śōdhya interval is 734.
3. Jyēshṭha	Vrishabha	30 (2)	26	17	38	30 (2)	10	31	3	307	307	
4. Āshāḍha	Mithuna	60 (4)	52	35	15	60 (4)	21	2	6	614	307	
5. Śrāvaṇa	Karka	91 (0)	18	52	53	91 (0)	7	33	9	923	309	
6. Bhādrapada	Simha	121 (2)	45	10	30	121 (2)	18	4	12	1229	306	
7. Āśvina	Kanyā	152 (5)	11	28	8	152 (5)	4	35	15	1536	307	
8. Kārttika	Tulā	182 (0)	37	45	46	182 (0)	15	6	18½	1844	308	
9. Mārgaśīrsha	Vriśchika	213 (3)	4	3	23	213 (3)	1	37	22	2152	306	
10. Pausha	Dhanus	243 (5)	30	21	1	243 (5)	12	8	25	2459	307	
11. Māgha	Makara	273 (0)	56	38	39	273 (0)	22	39	28	2766	307	
12. Phālguna	Kumbha	304 (3)	22	56	16	304 (3)	9	10	31	3074	308	
	Mīna	334 (5)	49	13	54	334 (5)	19	41	34	3381	307	
1. Chaitra	Mēsha (*of following year*)	365 (1)	15	31	31⅔	365 (1)	6	12	36.56	3689	308	

TABLE XX.A.

THE LENGTH OF EACH TRUE SIDEREAL SOLAR MONTH, FROM SAṀKRĀNTI TO SAṀKRĀNTI, DIVIDED BY 30; SHOWING THE TIME OCCUPIED BY THE SUN IN TRAVELLING ONE DEGREE (1°).

For use in calculating tropical, or sāyana, saṁkrāntis.

[N.B.—*The exact time is given in the Table, as this may be found useful for other purposes. In calculation for tropical saṁkrāntis the seconds may be left out of account as a rule, fractions above 30 s. being counted as one minute; and decimals may be worked only to four figures.*]

Name of sidereal month.	By the Ārya Siddhānta.					By the Sūrya Siddhānta.				
	D.	H.	M.	S.	In decimals of a day.	D.	H.	M.	S.	In decimals of a day.
1	2					3				
1. Mēsha	1	0	44	24	1.03083	1	0	44	53.6	1.03117
2. Vṛishabha	1	1	7	15.2	1.0467037	1	1	8	10.4	1.04734259
3. Mithuna	1	1	17	8.8	1.053573	1	1	18	56.8	1.05482407
4. Karka	1	1	10	27.2	1.0489256	1	1	6	48.8	1.04639814
5. Siṁha	1	0	39	40	1.0275463	1	0	48	53.6	1.0339537
6. Kanyā	1	0	21	55.2	1.01522	1	0	21	11.2	1.01471296
7. Tulā	0	23	55	21.6	0.9967	0	23	54	52.8	0.9964
8. Vṛiśchika	0	23	36	24	0.98361	0	23	35	32	0.98300925
9. Dhanus	0	23	28	49.6	0.97835138	0	23	27	15.2	0.977259
10. Makara	0	23	33	55.2	0.9818	0	23	33	30.4	0.981493518
11. Kumbha	0	23	50	48	0.9936	0	23	51	22.4	0.99400925
12. Mīna	1	0	16	15.4	1.0112893518	1	0	16	58.0186	1.011782622

TABLE XX.B.

THE **ayanāṁśas**, OR AMOUNT OF PRECESSION IN DEGREES, BEING THE LONGITUDINAL DISTANCE OF THE POINT OF THE VERNAL EQUINOX FROM THE FIRST POINT OF MĒSHA AT THE BEGINNING OF THE YEAR, ACCORDING TO THE SŪRYA SIDDHĀNTA.

(Adapted from Table XXXV. of Warren's *Kala Sankalita*, but with degrees and decimals added to facilitate calculation.)

Expired year of the Kaliyuga.	A.D. Julian year of century.	Collective amount of ayanāṁśas, or degrees of precession. In degrees.	In decimals.
1	2	3	
		° ′ ″	
3101	0	+ 7 29 6	+ 7.485°
3201	100	5 59 6	5.985°
3301	200	4 29 6	4.485°
3401	300	2 59 6	2.985°
3501	400	1 29 6	1.485°
3600	499	± 0 0 0	± 0
3601	500	— 0 0 54	— 0.015°
3701	600	1 30 54	1.515°
3801	700	3 0 54	3.015°
3901	800	4 30 54	4.515°
4001	900	6 0 54	6.015°
4101	1000	7 30 54	7.515°
4201	1100	9 0 54	9.015°
4301	1200	10 30 54	10.515°
4401	1300	12 0 54	12.015°
4501	1400	13 30 54	13.515°
4601	1500	15 0 54	15.015°
4701	1600	16 30 54	16.515°
4801	1700	18 0 54	18.015°
4901	1800	19 30 54	19.515°
5001	1900	21 0 54	21.015°
5101	2000	22 30 54	22.515°

Odd years.	Ayanāṁśas. In degrees.	In decimals.
4	5	
	° ′ ″	
1	0 0 54	0.015°
2	0 1 48	0.03°
3	0 2 42	0.045°
4	0 3 36	0.06°
5	0 4 30	0.075°
6	0 5 24	0.09°
7	0 6 18	0.105°
8	0 7 12	0.12°
9	0 8 6	0.135°
10	0 9 0	0.15°
20	0 18 0	0.3°
30	0 27 0	0.45°
40	0 36 0	0.6°
50	0 45 0	0.75°
60	0 54 0	0.9°
70	1 3 0	1.05°
80	1 12 0	1.2°
90	1 21 0	1.35°
100	1 30 0	1.5°
200	3 0 0	3.0°
300	4 30 0	4.5°
400	6 0 0	6.0°
500	7 30 0	7.5°
600	9 0 0	9.0°
700	10 30 0	10.5°
800	12 0 0	12.0°
900	13 30 0	13.5°
1000	15 0 0	15.0°

TABLE XXI.

COLLECTIVE DURATION IN DAYS OF MEAN LUNAR MONTHS FROM THE MOMENT OF MEAN NEW MOON OF AMĀNTA CHAITRA; AND THE SAME FOR MEAN TITHIS.

Collective duration of mean lunar months at each mean new moon.

Lunar month.	D.	Gh.	P.	Vip.	D.	H.	M.	S.	*a*
1	2				3				4
1 Chaitra	0	0	0	0	0	0	0	0	*a* is always 0, or 10,000, at every new-moon
2 Vaiśākha	29 (1)	31	50	7	29 (1)	12	44	3	
3 Jyēshṭha	59 (3)	3	40	14	59 (3)	1	28	6	
4 Āshāḍha	88 (4)	35	30	21	88 (4)	14	12	9	
5 Śrāvaṇa	118 (6)	7	20	28	118 (6)	2	56	11	
6 Bhādrapada	147 (0)	39	10	35	147 (0)	15	40	14	
7 Āśvina	177 (2)	11	0	42	177 (2)	4	24	17	
8 Kārttika	206 (3)	42	50	49	206 (3)	17	8	20	
9 Mārgaśīrsha	236 (5)	14	40	56	236 (5)	5	52	22	
10 Pausha	265 (6)	46	31	3	265 (6)	18	36	25	
11 Māgha	295 (1)	18	21	10	295 (1)	7	20	28	
12 Phālguna	324 (2)	50	11	17	324 (2)	20	4	31	
1 Chaitra (*of following year*)	354 (4)	22	1	24	354 (4)	8	48	34	

NOTES.

(i.) In practice vipalas under 30 may be ignored, those over 30 counting as one pala; and the same with seconds.

(ii.) The *a* (or *t*, which is the same thing in mean tithis) for the end of each tithi is the same as in *Ind. Cal.*, Table VIII., col. 3, *i.e.*, the *a* for the end of the 1st tithi is 333, for the end of the 2nd 667, &c.

(iii.) The length of every mean tithi is 59 gh. 3 p. 40.23 vip., or 23 h. 37 m. 28.09 s. For working purposes this may be taken as 59 gh. 4 p., or 23 h. 37 m.

(iv.) The figures in brackets are the week-days, beginning with 1 = Sunday.

Collective duration from mean new moon of each month to the end of each mean tithi as numbered in cols. 5 and 9.

No.	D.	Gh.	P.	Vp.	D.	H.	M.	S.	*a.*	No.	D.	Gh.	P.	Vip.	D.	H.	M.	S.	*a.*
5	6				7				8	9	10				11				12
1	0	59	3	40	0	23	37	28	(See Note ii.)	16	15 (1)	44	58	44	15 (1)	17	59	29	(See Note ii.)
2	1	58	7	20	1	23	14	56		17	16 (2)	44	2	24	16 (2)	17	36	58	
3	2	57	11	1	2	22	52	24		18	17 (3)	43	6	4	17 (3)	17	14	26	
4	3	56	14	41	3	22	29	52		19	18 (4)	42	9	44	18 (4)	16	51	54	
5	4	55	18	21	4	22	7	20		20	19 (5)	41	13	25	19 (5)	16	29	22	
6	5	54	22	1	5	21	44	49		21	20 (6)	40	17	5	20 (6)	16	6	50	
7	6	53	25	42	6	21	22	17		22	21 (0)	39	20	45	21 (0)	15	44	18	
8	7	52	29	22	7	20	59	45		23	22 (1)	38	24	25	22 (1)	15	21	46	
9	8 (1)	51	33	2	8 (1)	20	37	13		24	23 (2)	37	28	6	23 (2)	14	59	14	
10	9 (2)	50	36	42	9 (2)	20	14	41		25	24 (3)	36	31	46	24 (3)	14	36	42	
11	10 (3)	49	40	23	10 (3)	19	52	9		26	25 (4)	35	35	26	25 (4)	14	14	10	
12	11 (4)	48	44	3	11 (4)	19	29	37		27	26 (5)	34	39	6	26 (5)	13	51	39	
13	12 (5)	47	47	43	12 (5)	19	7	5		28	27 (6)	33	42	46	27 (6)	13	29	7	
14	13 (6)	46	51	23	13 (6)	18	44	33		29	28 (0)	32	46	27	28 (0)	13	6	35	
15	14 (0)	45	55	3	14 (0)	18	22	1		30	29 (1)	31	50	7	29 (1)	12	44	3	

TABLE XXII.

Correspondence of the Signs and the Nakshatras.

SIGNS. Name.	SIGNS. Begins at	NAKSHATRAS. No.	Name.	Equal-space System. Begins at	Equal-space System. Am'nt in sign.	System of Garga. Begins at	System of Garga. Am'nt in sign.	*Brāhma Siddhānta* System. Name.	*Brāhma Siddhānta* System. Begins at	*Brāhma Siddhānta* System. Amount in sign.
Mēsha	0°	1	Aśvinī	0° 0′	13° 20′	0° 0′	13° 20′	1 Aśvinī	0° 0′ 0″	13° 10′ 35″
		2	Bharaṇī	13° 20′	13° 20′	13° 20′	6° 40′	2 Bharaṇī	13° 10′ 35″	6° 35′ 17″
		3	Krittikā	26° 40′	3° 20′	20° 0′	10° 0′	3 Krittikā	19° 45′ 52″	10° 14′ 8″
Vrishabha	30°	3	Krittikā	....	10° 0′	....	3° 20′	3 Krittikā	....	2° 56′ 27″
		4	Rōhiṇī	40° 0′	13° 20′	33° 20′	20° 0′	4 Rōhiṇī	32° 56′ 27″	19° 45′ 53″
		5	Mrigaśiras	53° 20′	6° 40′	53° 20′	6° 40′	5 Mrigaśiras ...	52° 42′ 20″	7° 17′ 40″
Mithuna ..	60°	5	Mrigaśiras	....	6° 40′	....	6° 40′	5 Mrigaśiras ...	....	5° 52′ 55″
		6	Ārdrā	66° 40′	13° 20′	66° 40′	6° 40′	6 Ārdrā	65° 52′ 55″	6° 35′ 17″
		7	Punarvasu	80° 0′	10° 0′	73° 20′	16° 40′	7 Punarvasu ...	72° 28′ 12″	17° 31′ 48″
Karka ...	90°	7	Punarvasu	....	3° 20′	....	3° 20′	7 Punarvasu ...	....	2° 14′ 5″
		8	Pushya	93° 20′	13° 20′	93° 20′	13° 20′	8 Pushya	92° 14′ 5″	13° 10′ 35″
		9	Āślēshā	106° 40′	13° 20′	106° 40′	6° 40′	9 Āślēshā	105° 24′ 40″	6° 35′ 17″
		10	Maghā	....	....	113° 20′	6° 40′	10 Maghā	111° 59′ 57″	8° 0′ 3″
Siṁha	120°	10	Maghā	120° 0′	13° 20′	....	6° 40′	10 Maghā	....	5° 10′ 32″
		11	P. Phalgunī	133° 20′	13° 20′	126° 40′	13° 20′	11 P. Phalgunī ..	125° 10′ 32″	13° 10′ 35″
		12	U. Phalgunī	146° 40′	3° 20′	140° 0′	10° 0′	12 U. Phalgunī ..	138° 21′ 7″	11° 38′ 53″
Kanyā ...	150°	12	U. Phalgunī	....	10° 0′	....	10° 0′	12 U. Phalgunī ..	....	8° 7′ 0″
		13	Hasta	160° 0′	13° 20′	160° 0′	13° 20′	13 Hasta	158° 7′ 0″	13° 10′ 35″
		14	Chitrā	173° 20′	6° 40′	173° 20′	6° 40′	14 Chitrā	171° 17′ 35″	8° 42′ 25″
Tulā	180°	14	Chitrā	....	6° 40′	....	6° 40′	14 Chitrā	....	4° 28′ 10″
		15	Svāti	186° 40′	13° 20′	186° 40′	6° 40′	15 Svāti	184° 28′ 10″	6° 35′ 17″
		16	Viśākhā	200° 0′	10° 0′	193° 20′	16° 40′	16 Viśākhā	191° 3′ 27″	18° 56′ 33″
Vriśchika .	210°	16	Viśākhā	....	3° 20′	....	3° 20′	16 Viśākhā	....	0° 49′ 20″
		17	Anurādhā	213° 20′	13° 20′	213° 20′	13° 20′	17 Anurādhā ...	210° 49′ 20″	13° 10′ 35″
		18	Jyēshṭhā	226° 40′	13° 20′	226° 40′	6° 40′	18 Jyēshṭhā	223° 59′ 55″	6° 35′ 17″
		19	Mūla	....	....	233° 20′	6° 40′	19 Mūla	230° 35′ 12″	9° 24′ 48″
Dhanus ..	240°	19	Mūla	240° 0′	13° 20′	....	6° 40′	19 Mūla	....	3° 45′ 47″
		20	P. Ashāḍhā	253° 20′	13° 20′	246° 40′	13° 20′	20 P. Ashāḍhā ..	243° 45′ 47″	13° 10′ 35″
		21	U. Ashāḍhā	266° 40′	3° 20′	260° 0′	10° 0′	21 U. Ashāḍhā ..	256° 56′ 22″	13° 3′ 38″
Makara ..	270°	21	U. Ashāḍhā .... (*See Note* [1])	....	10° 0′	....	10° 0′	21 U. Ashāḍhā ..	....	6° 42′ 15″
								Abhijit	276° 42′ 15″	4° 14′ 15″
		22	Śravaṇa	280° 0′	13° 20′	280° 0′	13° 20′	22 Śravaṇa	280° 56′ 30″	13° 10′ 35″
		23	Dhanishṭhā	293° 20′	6° 40′	293° 20′	6° 40′	23 Dhanishṭhā...	294° 7′ 5″	5° 52′ 55″
Kumbha .	300°	23	Dhanishṭhā	....	6° 40′	....	6° 40′	23 Dhanishṭhā ..	....	7° 17′ 40″
		24	Śatatārakā	306° 40′	13° 20′	306° 40′	6° 40′	24 Śatatārakā ...	307° 17′ 40″	6° 35′ 17″
		25	P. Bhadrapadā .	320° 0′	10° 0′	313° 20′	13° 20′	25 P. Bhadrapadā	313° 52′ 57″	13° 10′ 35″
		26	U. Bhadrapadā .	....	....	326° 40′	3° 20′	26 U. Bhadrapadā	327° 3′ 32″	2° 56′ 28″
Mīna	330°	25	P. Bhadrapadā .	....	3° 20′	....	....	26 U. Bhadrapadā	....	16° 49′ 25″
		26	U. Bhadrapadā .	333° 20′	13° 20′	....	16° 40′	27 Rēvatī	346° 49′ 25″	13° 10′ 35″
		27	Rēvatī	346° 40′	13° 20′	346° 40′	13° 20′			

[1] The equal-space system and that of Garga have no nakshatra Abhijit. But Dr. Fleet tells me that some almanacs which follow the equal-space system show Abhijit, so far as it figures in the course of the sun, as a secondary or parenthetical detail, overlapping the end of Uttarā Ashādhā and the beginning of Śrāvaṇa. It begins at 276° 43′ and ends at 280° 52′.

TABLE XXIII.

For determination of nakshatras and yōgas.

(*See Text above, Art.* 112, *&c.*, "*Nakshatras, yōgas and karaṇas.*")

Arg. *c.*	*s.*	Diff.	Arg. *c.*	*s.*	Diff.	Arg. *c.*	*s.*	Diff.	Arg. *c.*	*s.*	Diff.	Arg. *c.*	*s.*	Diff.
0	7147	103	200	9204	101	400	1182	97	600	3111	97	800	5089	101
10	7250	104	210	9305	101	410	1279	97	610	3208	97	810	5190	102
20	7354	104	220	9406	101	420	1376	97	620	3305	97	820	5292	102
30	7458	104	230	9507	100	430	1473	96	630	3402	98	830	5394	101
40	7562	104	240	9607	100	440	1569	97	640	3500	98	840	5495	103
50	7666	103	250	9707	100	450	1666	96	650	3598	97	850	5598	102
60	7769	104	260	9807	100	460	1762	96	660	3695	99	860	5700	102
70	7873	103	270	9907	99	470	1858	96	670	3794	98	870	5802	103
80	7976	103	280	6	99	480	1954	96	680	3892	98	880	5905	103
90	8079	103	290	105	99	490	2050	97	690	3990	99	890	6008	103
100	8182	103	300	204	99	500	2147	96	700	4089	99	900	6111	103
110	8285	103	310	303	98	510	2243	96	710	4188	99	910	6214	103
120	8388	103	320	401	99	520	2339	96	720	4287	100	920	6317	104
130	8491	102	330	500	98	530	2435	96	730	4387	99	930	6421	103
140	8593	103	340	598	98	540	2531	97	740	4486	100	940	6524	104
150	8696	102	350	696	97	550	2628	96	750	4586	100	950	6628	103
160	8798	102	360	793	98	560	2724	97	760	4686	101	960	6731	104
170	8900	101	370	891	97	570	2821	96	770	4787	100	970	6835	104
180	9001	102	380	988	97	580	2917	97	780	4887	101	980	6939	104
190	9103	101	390	1085	97	590	3014	97	790	4988	101	990	7043	104
200	9204		400	1182		600	3111		800	5089		1000	7147	

AUXILIARY TABLE.

Diff. of *s.*	Last figure of Argument *c.*								
	1	2	3	4	5	6	7	8	9
	Add								
104	10	21	31	42	52	62	73	83	94
103	10	21	31	41	52	62	72	82	93
102	10	20	31	41	51	61	71	82	92
101	10	20	30	40	51	61	71	81	91
100	10	20	30	40	50	60	70	80	90
99	10	20	30	40	50	59	69	79	89
98	10	20	29	39	49	59	69	78	88
97	10	19	29	39	49	58	68	78	87
96	10	19	29	38	48	58	67	77	86

[This is Dr. Schram's Table for simplifying calculations of nakshatras and yōgas. From it, n being the nakshatra-index, y the yōga-index, s the apparent longitude of the sun, n and y are found from the formulæ $n = t + s$, and $y = s + n$ (or $= t + 2s$). s is found at once from Argument c by the Table and Auxiliary Table. See example in *Ind. Cal.*, pp. 81–97, where $c = 439$ and $t = 1463$. By this Table, for $c = 439$ we have $s = 1473$ (for Argument 430) + difference 96 between it and 440. With the Auxiliary Table "difference of s" 96 and last figure of Argument c, 9, we have to add 86. $1473 + 86 = 1559$. $n = t + s = 1463 + 1559 = 3022$, as in the example. $y = t + 2s = 1463 + 3118 = 4581$.]

TABLE XXIV.

COMMENCEMENT OF THE LUNI-SOLAR YEAR IN THE YEARS MENTIONED IN COLS. 1 AND 5 WHEN THE MEAN SYSTEM OF INTERCALATIONS OF LUNAR MONTHS IS USED, IN PLACE OF COLS. 19–25 OF TABLE I., "INDIAN CALENDAR." (Text, §§ 67–69.)

(*Asterisks mean Leap-years.*)

I. Concurrent year.		III. Commencement of the Luni-solar year, viz., the civil day of Chaitra śukla 1st, mean sunrise.						
				Moon's age.				
Kali.	A.D.	Day and month A.D.	Week-day.	Lunation parts elapsed (t).	Tithis elapsed.	a.	b.	c.
1	5	19	20	21	22	23	24	25
3412	310–11	18 Mar. (77)	0 Sat.	58	.174	52	795	282
3431	329–30	18 Mar. (77)	3 Tues.	180	.540	157	659	282
3450	*348–49	17 Mar. (77)	5 Thur.	78	.234	9924	486	279
3458	*356–57	19 Mar. (79)	3 Tues.	141	.423	84	602	285
3477	375–76	19 Mar. (78)	5 Thur.	52	.156	9851	430	282
3496	394–95	19 Mar. (78)	1 Sun.	232	.696	9956	293	282
3515	413–14	19 Mar. (78)	4 Wed.	319	.957	62	157	283
3526	*424–25	17 Mar. (77)	2 Mon.	69	.207	8	904	278
3534	*432–33	19 Mar. (79)	0 Sat.	327	.981	168	20	283
3553	451–52	20 Mar. (79)	3 Tues.	320	.960	273	884	283
3572	470–71	19 Mar. (78)	5 Thur.	45	.135	40	711	281
3580	478–79	21 Mar. (80)	3 Tues.	218	.654	200	828	286
3591	489–90	19 Mar. (78)	1 Sun.	223	.669	146	575	281
3599	497–98	21 Mar. (80)	6 Fri.	318	.954	306	691	286
3618	*516–17	20 Mar. (80)	1 Sun.	196	.588	72	519	284
3637	535–36	20 Mar. (79)	3 Tues.	95	.285	9839	346	281
3656	554–55	20 Mar. (79)	6 Fri.	222	.666	9945	210	281
3675	573–74	20 Mar. (79)	2 Mon.	250	.750	51	73	282
3694	*592–93	20 Mar. (80)	5 Thur.	243	.729	156	937	282
3702	*600–1	21 Mar. (81)	2 Mon.	133	.399	9977	17	284
3713	611–12	21 Mar. (80)	1 Sun.	270	.810	262	800	282
3721	619–20	22 Mar. (81)	5 Thur.	129	.387	83	881	285
3732	630–31	20 Mar. (79)	3 Tues.	69	.207	29	628	279
3740	638–39	22 Mar. (81)	1 Sun.	190	.570	189	744	285
3759	657–58	21 Mar. (80)	3 Tues.	37	.111	9956	571	282
3778	*676–77	21 Mar. (81)	6 Fri.	258	.774	61	435	282
3797	695–96	21 Mar. (80)	1 Sun.	109	.327	9828	262	280
3816	714–15	21 Mar. (80)	4 Wed.	175	.525	9934	126	280
3835	733–34	21 Mar. (80)	0 Sat.	170	.510	39	989	280
3843	741–42	22 Mar. (81)	4 Wed.	61	.183	9860	70	283
3854	*752–53	21 Mar. (81)	3 Tues.	175	.525	145	853	281

I. Concurrent year.		III. Commencement of the Luni-solar year, viz., the civil day of Chaitra śukla 1st, mean sunrise.						
				Moon's age.				
Kali.	A.D.	Day and month A.D.	Week-day.	Lunation parts elapsed (t).	Tithis elapsed.	a.	b.	c.
1	5	19	20	21	22	23	24	25
3862	*760–61	22 Mar. (82)	0 Sat.	49	.147	9966	933	283
3873	771–72	22 Mar. (81)	6 Fri.	254	.762	250	717	281
3881	779–80	23 Mar. (82)	3 Tues.	79	.237	72	797	283
3900	798–99	23 Mar. (82)	6 Fri.	200	.600	177	660	284
3919	817–18	22 Mar. (81)	1 Sun.	76	.288	9944	488	281
3938	*836–37	22 Mar. (82)	4 Wed.	303	.909	50	351	281
3957	855–56	22 Mar. (81)	6 Fri.	85	.255	9817	179	279
3965	863–64	24 Mar. (83)	4 Wed.	252	.756	9977	295	284
3976	874–75	22 Mar. (81)	2 Mon.	100	.300	9922	42	279
3984	882–83	23 Mar. (82)	6 Fri.	⊙–19	– .57	9743	122	282
3995	893–94	22 Mar. (81)	5 Thur.	91	273	28	906	279
4003	901–2	23 Mar. (82)	2 Mon.	⊙–23	– .69	9849	986	282
4014	*912–13	22 Mar. (82)	1 Sun.	136	.408	134	769	280
4022	*920–21	23 Mar. (83)	5 Thur.	⊙–17	– .51	9955	850	282
4041	939–40	24 Mar. (83)	1 Sun.	65	.195	60	713	282
4060	958–59	24 Mar. (83)	4 Wed.	241	.723	166	577	283
4079	977–78	23 Mar. (82)	6 Fri.	160	.480	9933	404	280
4098	*996–97	23 Mar. (83)	2 Mon.	318	.954	38	268	280
4106	*1004– 5	24 Mar. (84)	6 Fri.	115	.345	9860	348	283
4117	1015–16	23 Mar. (82)	4 Wed.	25	.75	9805	95	278
4125	1023–24	25 Mar. (84)	2 Mon.	242	.726	9965	211	283
4136	1034–35	23 Mar. (82)	0 Sat.	15	.45	9911	958	278
4144	1042–43	25 Mar. (84)	5 Thur.	276	.828	71	75	283
4155	1053–54	23 Mar. (82)	3 Tues.	32	.96	17	822	278
4163	1061–62	25 Mar. (84)	1 Sun.	264	.792	176	939	283
4182	*1080–81	25 Mar. (85)	4 Wed.	290	.870	282	802	284
4201	1099–1100	25 Mar. (84)	6 Fri.	89	.267	49	629	281

⊙ See *Indian Calendar*, § 101, para. 2, p. 56.

TABLE XXV.

CONVERSION OF GHAṬIKĀS AND PALAS INTO HOURS AND MINUTES, AND VICE VERSÂ, IN MEAN TIME.

Palas ghaṭikās.	M. H.	S. M.	Palas ghaṭikās.	M. H.	S. M.	Hours.	Gh.	P.	Minutes. Seconds.	Gh. P.	P. V.	V. Pra.	Minutes. Seconds.	Gh. P.	P. V.	V. Pra.
1		24	31	12	24	1	2	30	1		2	30	31	1	17	30
2		48	32	12	48	2	5	0	2		5	0	32	1	20	0
3	1	12	33	13	12	3	7	30	3		7	30	33	1	22	30
4	1	36	34	13	36	4	10	0	4		10	0	34	1	25	0
5	2	0	35	14	0	5	12	30	5		12	30	35	1	27	30
6	2	24	36	14	24	6	15	0	6		15	0	36	1	30	0
7	2	48	37	14	48	7	17	30	7		17	30	37	1	32	30
8	3	12	38	15	12	8	20	0	8		20	0	38	1	35	0
9	3	36	39	15	36	9	22	30	9		22	30	39	1	37	30
10	4	0	40	16	0	10	25	0	10		25	0	40	1	40	0
11	4	24	41	16	24	11	27	30	11		27	30	41	1	42	30
12	4	48	42	16	48	12	30	0	12		30	0	42	1	45	0
13	5	12	43	17	12	13	32	30	13		32	30	43	1	47	30
14	5	36	44	17	36	14	35	0	14		35	0	44	1	50	0
15	6	0	45	18	0	15	37	30	15		37	30	45	1	52	30
16	6	24	46	18	24	16	40	0	16		40	0	46	1	55	0
17	6	48	47	18	48	17	42	30	17		42	30	47	1	57	30
18	7	12	48	19	12	18	45	0	18		45	0	48	2	0	0
19	7	36	49	19	36	19	47	30	19		47	30	49	2	2	30
20	8	0	50	20	0	20	50	0	20		50	0	50	2	5	0
21	8	24	51	20	24	21	52	30	21		52	30	51	2	7	30
22	8	48	52	20	48	22	55	0	22		55	0	52	2	10	0
23	9	12	53	21	12	23	57	30	23		57	30	53	2	12	30
24	9	36	54	21	36	24	60	0	24	1	0	0	54	2	15	0
25	10	0	55	22	0				25	1	2	30	55	2	17	30
26	10	24	56	22	24				26	1	5	0	56	2	20	0
27	10	48	57	22	48				27	1	7	30	57	2	22	30
28	11	12	58	23	12				28	1	10	0	58	2	25	0
29	11	36	59	23	36				29	1	12	30	59	2	27	30
30	12	0	60	24	0				30	1	15	0	60	2	30	0

TABLE XXVIII.

THE SIXTY-SAMVATSARA CYCLE OF JUPITER.

Mean-sign system by the **Sūrya Siddhānta with the bīja.**

Year of the Kaliyuga (expired).	Christian year.	Number of days by which 1, Prabhava began after apparent Mēsha saṁkrānti.	Expunged saṁvatsaras.
1	2	3	4
4540	1439-40	320.6033	
4600	1499-500	67.1569	
(*4615*)	(*1514-5*)	....	16 Chitrabhānu.
4659	1558-9	178.9694	
(*4701*)	(*1600-1*)	....	43 Saumya.
4718	1617-8	290.7818	
4778	1677-8	37.3355	
(*4786*)	(*1685-6*)	....	9 Yuvan.
4837	1736-7	149.1479	
(*4872*)	(*1771-2*)	....	36 Śubhakṛit.
4896	1795-6	260.9603	
4956	1855-6	7.5140	
(*4957*)	(*1856-7*)	....	2 Vibhava.
5015	1914-5	119.3264	
(*5043*)	(*1942-3*)	....	29 Manmatha.
5074	1973-4	231.1389	
(*5128*)	(*2027-8*)	....	55 Durmati.
5133	2032-3	342.9513	

To obtain a final result in accordance with Dr. Schram's altered valuation of the śōdhya, deduct 2 m. 35 s. from the final result obtained by use of this Table; or deduct 0.00179 d. from the result of the first operation in decimals of a day. (*Text*, § 39 c.)

TABLE XXVIII.A.

THE SIXTY-SAMVATSARA CYCLE OF JUPITER.

Mean-sign system by the **Sūrya Siddhānta with the bīja.**

The number of days and decimals less than the day given in Table XXVIII. by which each saṁvatsara begins after apparent Mēsha saṁkrānti.

No.	Saṁvatsara.	Number of days.	No.	Saṁvatsara.	Number of days.
1	2	3	1	2	3
1	Prabhava	0.0000	31	Hēmalamba	126.7232
2	Vibhava	4.2241	32	Vilamba	130.9473
3	Śukla	8.4482	33	Vikārin	135.1714
4	Pramōda	12.6723	34	Śārvarin	139.3955
5	Prajāpati	16.8964	35	Plava	143.6196
6	Aṅgiras	21.1205	36	Śubhakṛit	147.8437
7	Śrīmukha	25.3446	37	Śōbhana	152.0678
8	Bhāva	29.5687	38	Krōdhin	156.2919
9	Yuvan	33.7928	39	Viśvāvasu	160.5160
10	Dhātṛi	38.0169	40	Parābhava	164.7401
11	Īśvara	42.2411	41	Plavaṅga	168.9642
12	Bahudhānya	46.4652	42	Kīlaka	173.1883
13	Pramāthin	50.6893	43	Saumya	177.4124
14	Vikrama	54.9134	44	Sādhāraṇa	181.6365
15	Vṛisha	59.1375	45	Virōdhakṛit	185.8606
16	Chitrabhānu	63.3616	46	Paridhāvin	190.0847
17	Subhānu	67.5857	47	Pramādin	194.3088
18	Tāraṇa	71.8098	48	Ānanda	198.5330
19	Pārthiva	76.0339	49	Rākshasa	202.7571
20	Vyaya	80.2580	50	Anala	206.9812
21	Sarvajit	84.4821	51	Piṅgala	211.2053
22	Sarvadhārin	88.7062	52	Kālayukta	215.4294
23	Virōdhin	92.9303	53	Siddhārthin	219.6535
24	Vikṛita	97.1544	54	Raudra	223.8776
25	Khara	101.3785	55	Durmati	228.1017
26	Nandana	105.6026	56	Dundubhi	232.3258
27	Vijaya	109.8267	57	Rudhirōdgārin	236.5499
28	Jaya	114.0508	58	Raktāksha	240.7740
29	Manmatha	118.2750	59	Krōdhana	244.9981
30	Durmukha	122.4991	60	Kshaya	249.2222
			1	Prabhava (*of next cycle*)	253.4463

TABLE XXIX.

The sixty-saṁvatsara cycle of Jupiter.

Mean-sign system by the **Ārya Siddhānta.**

Year of the Kaliyuga (expired).	Christian year.	Number of days by which 1 Prabhava began after apparent Mēsha saṁkrānti.	Expunged saṁvatsara.
1	2	3	4
	B.C.		
(0)	*(3102–1)*	....	27 Vijaya
33	3069–8	223.3823	
⋮	⋮	⋮	
	A.D.		
3117	16–17	156.3765	
(3153)	*(52–53)*	....	37 Śōbhana.
3176	75–6	267.4752	
3236	135–6	13.3152	
(3239)	*(138–39)*	....	4 Pramōda.
3295	194–5	124.4139	
(3324)	*(223–24)*	....	30 Durmukha.
3354	253–4	235.5126	
(3409)	*(308–09)*	....	56 Dundubhi.
3413	312–3	346.6113	
3473	372–3	92.4514	
(3494)	*(393–94)*	....	22 Sarvadhārin.
3532	431–2	203.5501	
(3580)	*(479–80)*	....	49 Rākshasa.
3591	490–1	314.6488	
3651	550–1	60.4888	
(3665)	*(564–65)*	....	15 Vṛisha.
3710	609–10	171.5875	
(3750)	*(649–50)*	....	41 Plavaṅga.
3769	668–9	282.6863	
3829	728–9	28.5263	
(3835)	*(734–35)*	....	7 Śrīmukha.
3888	787–8	139.6250	
(3920)	*(819–20)*	....	33 Vikārin.
3947	846–7	250.7237	
(4006)	*(905–06)*	....	60 Kshaya.
4006	905–6	361–8224	

Year of the Kaliyuga (expired).	Christian year.	Number of days by which 1 Prabhava began after apparent Mēsha saṁkrānti.	Expunged saṁvatsara.
1	2	3	4
4066	965–6	107.6625	
(4091)	*(990–91)*	....	26 Nandana.
4125	1024–5	218.7612	
(4176)	*(1075–76)*	....	52 Kālayukta.
4184	1083–4	329–8599	
4244	1143–4	75.6999	
(4261)	*(1060–61)*	....	18 Tāraṇa.
4303	1202–3	186.7986	
(4347)	*(1246–47)*	....	45 Virōdhakṛit
4362	1261–2	297.8974	
4422	1321–2	43.7374	
(4432)	*(1331–32)*	....	11 Īśvara.
4481	1380–1	154.8361	
(4517)	*(1416–17)*	....	37 Śōbhana.
4540	1439–40	265.9348	
4600	1499–1500	11.7748	
(4602)	*(1501–02)*	....	3 Śukla.
4659	1558–9	122.8736	
(4688)	*(1587–88)*	....	30 Durmukha.
4718	1617–8	233.9723	
(4773)	*(1672–73)*	....	56 Dundubhi.
4777	1676–7	345.0710	
4837	1736–7	90.9110	
(4858)	*(1757–58)*	....	22 Sarvadhārin.
4896	1795–6	202.0097	
(4943)	*(1842–43)*	....	48 Ānanda.
4955	1854–5	313.1084	
5015	1914–5	58.9485	
(5028)	*(1927–28)*	....	14 Vikrama.
5074	1973–4	170.0472	
(5114)	*(2013–14).*	....	41 Plavaṅga.
5133	2032–3	281–1459	

To obtain a final result in accordance with Dr. Schram's altered valuation of the śōdhya, deduct 1 m. 4 s. from the final result obtained by use of this Table; or deduct 0.000738 d. from the result of the first operation in decimals of a day.

TABLE XXIX.A.

THE SIXTY-SAṀVATSARA CYCLE OF JUPITER.

Mean-sign system by the **Ārya Siddhānta.**

The number of days and decimals less than the day given in Table XXIX. by which each saṁvatsara begins after apparent Mēsha saṁkrānti.

No.	Saṁvatsara.	Number of days.	No.	Saṁvatsara.	Number of days.
1	2	3	1	2	3
1	Prabhava	0.0000	31	Hēmalamba	127.0880
2	Vibhava	4.2360	32	Vilamba	131.3160
3	Śukla	8.4720	33	Vikārin	135.5520
4	Pramōda	12.7080	34	Śārvarin	139.7880
5	Prajāpati	16.9440	35	Plava	144.0240
6	Aṅgiras	21.1800	36	Śubhakṛit	148.2600
7	Śrīmukha	25.4160	37	Śōbhana	152.4960
8	Bhāva	29.6520	38	Krōdhin	156.7320
9	Yuvan	33.8880	39	Viśvāvasu	160.9680
10	Dhātṛi	38.1240	40	Parābhava	165.2040
11	Īśvara	42.3600	41	Plavaṅga	169.4400
12	Bahudhānya	46.5960	42	Kīlaka	173.6760
13	Pramāthin	50.8320	43	Saumya	177.9120
14	Vikrama	55.0680	44	Sādhāraṇa	182.1480
15	Vṛisha	59.3040	45	Virōdhakṛit	186.3840
16	Chitrabhānu	63.5400	46	Paridhāvin	190.6200
17	Subhānu	67.7760	47	Pramādin	194.8560
18	Tāraṇa	72.0120	48	Ānanda	199.0920
19	Pārthiva	76.2480	49	Rākshasa	203.3280
20	Vyaya	80.4840	50	Anala	207.5640
21	Sarvajit	84.7200	51	Piṅgala	211.8000
22	Sarvadhārin	88.9560	52	Kālayukta	216.0360
23	Virōdhin	93.1920	53	Siddhārthin	220.2720
24	Vikṛita	97.4280	54	Raudra	224.5080
25	Khara	101.6640	55	Durmati	228.7440
26	Nandana	105.9000	56	Dundubhi	232.9800
27	Vijaya	110.1360	57	Rudhirōdgārin	237.2160
28	Jaya	114.3720	58	Raktāksha	241.4520
29	Manmatha	118.6080	59	Krōdhana	245.6880
30	Durmukha	122.8440	60	Kshaya	249.9240
			1	Prabhava (*of next cycle*)	254.1600

TABLE XXX.

THE SIXTY-SAṀVATSARA CYCLE OF JUPITER.

Mean-sign system by the **Original Sūrya Siddhanta.**

This Table is prepared for MEAN Mēsha saṁkrānti, and in this respect differs from the others.

Year of the Kaliyuga (expired).	Christian year.	Number of days by which No. 1 Prabhava began after MEAN Mēsha saṁkrānti.	Expunged saṁvatsara.
1	2	3	4
K.Y.	B.C.		
(0)	*(3102-1)*	....	27 Vijaya.
33	3069-8	221.36955	
:	:	:	
:	A.D.	:	
3117	16-17	166.7342	
(3156)	*(55-56)*	....	40 Parābhava.
3176	75-76	278.0708	
3236	135-36	24.1487	
(3241)	*(140-41)*	....	6. Aṅgiras.
3295	194-95	135.4853	
(3327)	*(226-27)*	....	33 Vikārin.
3354	253-54	246.8219	
(3412)	*(311-12)*	....	59 Krōdhana.
3413	312-13	358-1586	
3473	372-73	104.2364	
(3497)	*(396-97)*	....	25 Khara.
3532	431-32	215.5731	
(3583)	*(482-83)*	....	52 Kālayukta.
3591	490-91	326.9097	
3651	550-51	72.9876	
(3668)	*(567-68)*	....	18 Tāraṇa.
3710	609-10	184.3242	
(3753)	*(652-53)*	....	44 Sādhāraṇa.
3769	668-69	295.6608	
3829	728-29	41.7387	
(3838)	*(737-38)*	....	10 Dhātṛi.
3888	787-88	153.0753	
(3924)	*(823-24)*	....	37 Śōbhana.
3947	846-47	264.4120	
4007	906-07	10.4898	
(4009)	*(908-09)*	....	3 Śukla.
K.Y.	A.D.		
4066	965-66	121.8265	
(4094)	*(993-94)*	....	29 Manmatha.
4125	1024-25	233.1631	
(4180)	*(1079-80)*	....	56 Dundubhi.
4184	1083-84	344.4997	
4244	1143-44	90.5776	
(4265)	*(1164-65)*	....	22 Sarvadhārin.
4303	1202-03	201.9142	
(4350)	*(1249-50)*	....	48 Ānanda.
4362	1261-62	313.2508	
4422	1321-22	59.3287	
(4436)	*(1335-36)*	....	15 Vṛisha.
4481	1380-81	170.6654	
(4521)	*(1420-21)*	....	41 Plavaṅga.
4540	1439-40	282.0020	
4600	1499-500	28.0799	
(4606)	*(1505-06)*	....	7 Śrīmukha.
4659	1558-59	139.4165	
(4692)	*(1591-92)*	....	34 Śārvarin.
4718	1617-18	250.7531	
(4777)	*(1676-77)*	....	60 Kshaya.
4777	1676-77	362.0897[1]	

[This Table is based on calculations made with the value of the śōdhya in K.Y. 0 as fixed by the late Sh. B. Dikshit.]

It is needless to continue this Table further, this *Siddhānta* having been for centuries out of use by the end of the 17th century A.D.

TABLE XXX.A.

THE SIXTY-SAṀVATSARA CYCLE OF JUPITER.

Mean-sign system by the **Original Sūrya Siddhānta.**

The number of days and decimals, less than the day given in Table XXX., by which each saṁvatsara begins after MEAN Mēsha saṁkrānti in its solar year.

No.	Saṁvatsara.	Number of days.	No.	Saṁvatsara.	Number of days.
1	2	3	1	2	3
1	Prabhava	0.0000	31	Hēmalamba	126.9611
2	Vibhava	4.2320	32	Vilamba	131.1931
3	Śukla	8.4641	33	Vikārin	135.4251
4	Pramōda	12.6961	34	Śārvarin	139.6572
5	Prajāpati	16.9281	35	Plava	143.8892
6	Aṅgiras	21.1602	36	Śubhakṛit	148.1212
7	Śrīmukha	25.3922	37	Śōbhana	152.3533
8	Bhāva	29.6242	38	Krōdhin	156.5853
9	Yuvan	33.8563	39	Viśvāvasu	160.8173
10	Dhātṛi	38.0883	40	Parābhava	165.0494
11	Īśvara	42.3204	41	Plavaṅga	169.2814
12	Bahudhānya	46.5524	42	Kīlaka	173.5135
13	Pramāthin	50.7844	43	Saumya	177.7455
14	Vikrama	55.0165	44	Sādhāraṇa	181.9775
15	Vṛisha	59.2485	45	Virōdhakṛit	186.2096
16	Chitrabhānu	63.4805	46	Paridhāvin	190.4416
17	Subhānu	67.7126	47	Pramādin	194.6736
18	Tāraṇa	71.9446	48	Ānanda	198.9057
19	Pārthiva	76.1766	49	Rākshasa	203.1377
20	Vyaya	80.4087	50	Anala	207.3697
21	Sarvajit	84.6407	51	Piṅgala	211.6018
22	Sarvadhārin	88.8727	52	Kālayukta	215.8338
23	Virōdhin	93.1048	53	Siddhārthin	220.0658
24	Vikṛita	97.3368	54	Raudra	224.2979
25	Khara	101.5689	55	Durmati	228.5299
26	Nandana	105.8009	56	Dundubhi	232.7619
27	Vijaya	110.0329	57	Rudhirōdgārin	236.9940
28	Jaya	114.2650	58	Raktāksha	241.2260
29	Manmatha	118.4970	59	Krōdhana	245.4581
30	Durmukha	122.7290	60	Kshaya	249.6901
			1	Prabhava (*of next cycle*)	253.9221

TABLE XXXI.

THE SIXTY-SAṀVATSARA CYCLE OF JUPITER.

Mean-sign system by the **Brāhma Siddhānta** *and* **Siddhānta Sirōmaṇi.**

Year of the Kaliyuga (expired).	Christian year.	Number of days by which 1 Prabhava began after apparent Mēsha saṁkrānti.	Expunged saṁvatsara.	Year of the Kaliyuga (expired).	Christian year.	Number of days by which 1 Prabhava began after apparent Mēsha saṁkrānti.	Expunged saṁvatsara.
1	2	3	4	1	2	3	4
	B.C.						
33	3069-8	229.8221		4125	1024-25	215.1268	
	A.D.			*(4175)*	*(1074-75)*	....	51 Piṅgala.
3117	16-17	155.2242		4184	1083-84	326.0794	
(3153)	*(52-53)*	....	37 Śōbhana.	4244	1143-44	71.7736	
3176	75-76	266.1768		*(4260)*	*(1159-60)*	....	17 Subhānu.
3236	135-36	11.8710		4303	1202-03	182.7262	
(3238)	*(137-38)*	....	3 Śukla.	*(4346)*	*(1245-46)*	....	44 Sādhāraṇa.
3295	194-95	122.8236		4362	1261-62	293.6789	
(3323)	*(222-23)*	....	29 Manmatha.	4422	1321-22	39.3731	
3354	253-54	233.7763		*(4431)*	*(1330-31)*	....	10 Dhātṛi.
(3409)	*(308-09)*	....	56 Dundubhi.	4481	1380-81	150.3257	
3413	312-13	344.7289		*(4516)*	*(1415-16)*	....	36 Śubhakṛit.
3473	372-73	90.4231		4540	1439-40	261.2783	
(3494)	*(393-94)*	....	22 Sarvadhārin.	4600	1499-500	6.9725	
3532	431-32	201.3757		*(4601)*	*(1500-01)*	....	2 Vibhava.
(3579)	*(478-79)*	....	48 Ānanda.	4659	1558-59	117.9252	
3591	490-91	312.3284		*(4686)*	*(1585-86)*	....	28 Jaya.
3651	550-51	58.0226		4718	1617-18	228.8778	
(3664)	*(563-64)*	....	14 Vikrama.	*(4772)*	*(1671-72)*	....	55 Durmati.
3710	609-10	168.9752		4777	1676-77	339.8304	
(3749)	*(648-49)*	....	40 Parābhava.	4837	1736-37	85.5246	
3769	668-69	279.9278		*(4857)*	*(1756-57)*	....	21 Sarvajit.
3829	728-29	25.6220		4896	1795-96	196.4773	
(3835)	*(734-35)*	....	7 Śrīmukha.	*(4942)*	*(1841-42)*	....	47 Pramādin.
3888	787-88	136.5747		4955	1854-55	307.4299	
(3920)	*(819-20)*	....	33 Vikārin.	5015	1914-15	53.1241	
3947	846-47	247.5273		*(5027)*	*(1926-27)*	....	13 Pramāthin.
(4005)	*(904-05)*	....	59 Krōdhana.	5074	1973-74	164.0767	
4006	905-06	358.4799		*(5112)*	*(2011-12)*	....	39 Viśvāvasu.
4066	965-66	104.1741		5133	2032-33	275.0294	
(4090)	*(989-90)*	....	25 Khara.				

N.B. This Table is based on Dr. Schram's valuation of the śōdhya in K.Y. 0.

TABLE XXXI.A.

The sixty-saṁvatsara cycle of Jupiter.

Mean-sign system by the **Brāhma Siddhānta** *and* **Siddhānta Śirōmaṇi**.

The number of days and decimals less than the day given in Table XXXI. by which each saṁvatsara begins after apparent Mēsha saṁkrānti.

No.	Saṁvatsara.	Number of days.	No.	Saṁvatsara.	Number of days.
1	2	3	1	2	3
1	Prabhava	0.0000	31	Hemalamba	127.1529
2	Vibhava	4.2384	32	Vilamba	131.3913
3	Śukla	8.4769	33	Vikārin	135.6298
4	Pramōda	12.7153	34	Śārvarin	139.8682
5	Prajāpati	16.9537	35	Plava	144.1066
6	Aṅgiras	21.1922	36	Śubhakṛit	148.3451
7	Śrīmukha	25.4306	37	Śōbhana	152.5835
8	Bhāva	29.6690	38	Krōdhin	156.8219
9	Yuvan	33.9074	39	Viśvāvasu	161.0603
10	Dhātṛi	38.1459	40	Parābhava	165.2988
11	Īśvara	42.3843	41	Plavaṅga	169.5372
12	Bahudhānya	46.6227	42	Kīlaka	173.7756
13	Pramāthin	50.8612	43	Saumya	178.0141
14	Vikrama	55.0996	44	Sādhāraṇa	182.2525
15	Vṛisha	59.3380	45	Virōdhakṛit	186.4909
16	Chitrabhānu	63.5765	46	Paridhāvin	190.7294
17	Subhānu	67.8149	47	Pramādin	194.9678
18	Tāraṇa	72.0533	48	Ānanda	199.2062
19	Pārthiva	76.2917	49	Rākshasa	203.4446
20	Vyaya	80.5302	50	Anala	207.6831
21	Sarvajit	84.7686	51	Piṅgala	211.9215
22	Sarvadhārin	89.0070	52	Kālayukta	216.1599
23	Virōdhin	93.2455	53	Siddhārthin	220.3984
24	Vikṛita	97.4839	54	Raudra	224.6368
25	Khara	101.7223	55	Durmati	228.8752
26	Nandana	105.9608	56	Dundubhi	233.1137
27	Vijaya	110.1992	57	Rudhirōdgārin	237.3521
28	Jaya	114.4376	58	Raktāksha	241.5905
29	Manmatha	118.6760	59	Krōdhana	245.8290
30	Durmukha	122.9145	60	Kshaya	250.0674
			1	Prabhava (*of the following cycle*)	254.3058

TABLE XXXII.

THE TWELVE-YEAR CYCLE OF JUPITER.

Showing the correspondence of the saṁvatsaras of the twelve-year cycle of Jupiter with those of the sixty-year cycle, by Jupiter's mean longitude.

Saṁvatsaras of the 60-year cycle.					Saṁvatsara of 12-year cycle.	Mean Jupiter in sign.
1					2	3
1 Prabhava.	13 Pramāthin.	25 Khara.	37 Śōbhana.	49 Rākshasa.	Mahā Śrāvaṇa.	11 Kumbha.
2 Vibhava.	14 Vikrama.	26 Nandana.	38 Krōdhin.	50 Anala.	Mahā Bhādrapada.	12 Mīna.
3 Śukla.	15 Vṛisha.	27 Vijaya.	39 Viśvāvasu.	51 Piṅgala.	Mahā Āśvina.	1 Mēsha.
4 Pramōda.	16 Chitrabhānu.	28 Jaya.	40 Parābhava.	52 Kālayukta.	Mahā Kārttika.	2 Vṛishabha.
5 Prajāpati.	17 Subhānu.	29 Manmatha.	41 Plavaṅga.	53 Siddhārthin.	Mahā Mārgaśīrsha.	3 Mithuna.
6 Aṅgiras.	18 Tāraṇa.	30 Durmukha.	42 Kīlaka.	54 Raudra.	Mahā Pausha.	4 Karka.
7 Śrīmukha.	19 Pārthiva.	31 Hēmalamba.	43 Saumya.	55 Durmati.	Mahā Māgha.	5 Siṁha.
8 Bhāva.	20 Vyaya.	32 Vilamba.	44 Sādhāraṇa.	56 Dundubhi.	Mahā Phālguna.	6 Kanyā.
9 Yuvan.	21 Sarvajit.	33 Vikārin.	45 Virōdhakṛit.	57 Rudhirōd-gārin.	Mahā Chaitra.	7 Tulā.
10 Dhātṛi.	22 Sarvadhārin.	34 Śārvarin.	46 Paridhāvin.	58 Raktāksha.	Mahā Vaiśākha.	8 Vṛiśchika.
11 Īśvara.	23 Virōdhin.	35 Plava.	47 Pramādin.	59 Krōdhana.	Mahā Jyēshṭha.	9 Dhanus.
12 Bahudhānya.	24 Vikṛita.	36 Śubhakṛit.	48 Ānanda.	60 Kshaya.	Mahā Āshāḍha.	10 Makara.

TABLE XXXIII.

For finding the mean place of Jupiter.

Argument = the number of solar years between Kaliyuga 1 current and the given Kaliyuga current year.

	Jupiter's mean place at mean Mēsha saṁkrānti of K.Y. 1 current.				Deduct constant.			
	s.	°	′	″	s.	°	′	″
Present Sūrya Siddhānta	0	0	0	0	0	0	0	0
Present Sūrya Siddhānta with bīja	0	0	0	0	0	0	0	0
First Ārya Siddhānta	0	0	0	0	0	0	0	0
Original Sūrya Siddhānta	0	0	0	0	0	0	0	0
Brāhma Siddhānta and Siddhānta Śirōmaṇi	11	29	27	36	0	0	32	24

Arg: No. of years.	Sūrya Siddhānta. Original Sūrya Siddhānta.				Sūrya Siddhānta with bīja.				First Ārya Siddhānta.				Brāhma Siddhānta and Siddhānta Śirōmaṇi.			
	s.	°	′	″	s.	°	′	″	s.	°	′	″	s.	°	′	″
1	1	0	21	6	1	0	21	4	1	0	21	7	1	0	21	8
2	2	0	42	12	2	0	42	7	2	0	42	14	2	0	42	16
3	3	1	3	18	3	1	3	11	3	1	3	22	3	1	3	24
4	4	1	24	24	4	1	24	14	4	1	24	29	4	1	24	32
5	5	1	45	30	5	1	45	18	5	1	45	36	5	1	45	40
6	6	2	6	36	6	2	6	22	6	2	6	43	6	2	6	48
7	7	2	27	42	7	2	27	25	7	2	27	50	7	2	27	56
8	8	2	48	48	8	2	48	29	8	2	48	58	8	2	49	5
9	9	3	9	54	9	3	9	32	9	3	10	5	9	3	10	11
10	10	3	31	0	10	3	30	36	10	3	31	12	10	3	31	19
20	8	7	2	0	8	7	1	12	8	7	2	24	8	7	2	39
30	6	10	33	0	6	10	31	48	6	10	33	36	6	10	33	58
40	4	14	4	0	4	14	2	24	4	14	4	48	4	14	5	18
50	2	17	35	0	2	17	33	0	2	17	36	0	2	17	36	37
60	0	21	6	0	0	21	3	36	0	21	7	12	0	21	7	56
70	10	24	37	0	10	24	34	12	10	24	38	24	10	24	39	16
80	8	28	8	0	8	28	4	48	8	28	9	36	8	28	10	35
90	7	1	39	0	7	1	35	24	7	1	40	48	7	1	41	54
100	5	5	10	0	5	5	6	0	5	5	12	0	5	5	13	14
200	10	10	20	0	10	10	12	0	10	10	24	0	10	10	26	28
300	3	15	30	0	3	15	18	0	3	15	36	0	3	15	39	41
400	8	20	40	0	8	20	24	0	8	20	48	0	8	20	52	55
500	1	25	50	0	1	25	30	0	1	26	0	0	1	26	6	9
600	7	1	0	0	7	0	36	0	7	1	12	0	7	1	19	23
700	0	6	10	0	0	5	42	0	0	6	24	0	0	6	32	36
800	5	11	20	0	5	10	48	0	5	11	36	0	5	11	45	50
900	10	16	30	0	10	15	54	0	10	16	48	0	10	16	59	4
1000	3	21	40	0	3	21	0	0	3	22	0	0	3	22	12	18
2000	7	13	20	0	7	12	0	0	7	14	0	0	7	14	24	35
3000	11	5	0	0	11	3	0	0	11	6	0	0	11	6	36	53
4000	2	26	40	0	2	24	0	0	2	28	0	0	2	28	49	10
5000	6	18	20	0	6	15	0	0	6	20	0	0	6	21	1	28

TABLE XXXIV.

Mean motion of Jupiter and Sun.

Argument = the number of days, hours and minutes between mean Mēsha saṁkrānti and the given moment.

(Applicable to all the Siddhāntas.)

Arg: No. of days.	Jupiter. s.	°	′	″	Sun. s.	°	′	″	*Arg:* No. of days.	Jupiter. s.	°	′	″	Sun. s.	°	′	″
1	0	0	4	59	0	0	59	8	30	0	2	29	34	0	29	34	5
2	0	0	9	58	0	1	58	16	40	0	3	19	26	1	9	25	27
3	0	0	14	57	0	2	57	25	50	0	4	9	17	1	19	16	48
4	0	0	19	57	0	3	56	33	60	0	4	59	7	1	29	8	10
5	0	0	24	56	0	4	55	41	70	0	5	49	0	2	8	59	32
6	0	0	29	55	0	5	54	49	80	0	6	38	52	2	18	50	54
7	0	0	34	54	0	6	53	57	90	0	7	28	43	2	28	42	15
8	0	0	39	53	0	7	53	5	100	0	8	18	35	3	8	33	37
9	0	0	44	52	0	8	52	14	200	0	16	37	9	6	17	7	14
10	0	0	49	51	0	9	51	22	300	0	24	55	44	9	25	40	51
20	0	1	39	43	0	19	42	43									

Arg: No. of hours.	Jupiter. ′	″	Sun. ′	″	*Arg:* No. of minutes.	Jupiter. ′	″	Sun. ′	″	*Arg:* No. of ghaṭikās.	Jupiter. ′	″	Sun. ′	″	*Arg:* No. of palas.	Jupiter. ′	″	Sun. ′	″
1	0	12	2	28	1	0	0.2	0	2½	1	0	5	0	59	1	0	0.1	0	1
2	0	25	4	56	2	0	0.4	0	5	2	0	10	1	58	2	0	0.2	0	2
3	0	37	7	24	3	0	0.6	0	7	3	0	15	2	57	3	0	0.2	0	3
4	0	50	9	51	4	0	0.8	0	10	4	0	20	3	57	4	0	0.3	0	4
5	1	2	12	19	5	0	1	0	12	5	0	25	4	56	5	0	0.4	0	5
6	1	15	14	47	6	0	1.2	0	15	6	0	30	5	55	6	0	0.5	0	6
7	1	27	17	15	7	0	1.4	0	17	7	0	35	6	54	7	0	0.6	0	7
8	1	39	19	43	8	0	1.6	0	20	8	0	40	7	53	8	0	0.7	0	8
9	1	52	22	11	9	0	1.8	0	22	9	0	45	8	52	9	0	0.7	0	9
10	2	5	24	38	10	0	2	0	25	10	0	50	9	51	10	0	0.8	0	10
20	4	9	49	17	20	0	4	0	49	20	1	40	19	43	20	0	1.7	0	20
					30	0	6	1	14	30	2	30	29	34	30	0	2.5	0	30
					40	0	8	1	39	40	3	19	39	25	40	0	3.3	0	39
					50	0	10	2	3	50	4	9	49	17	50	0	4.2	0	49

Śōdhya:

	d.	d.	h.	m.	s.	d.	gh.	p.	v.	
Sūrya Siddhānta (with and without the bīja)	$2.17069\dot{4}$	= 2	4	5	48	= 2	10	14	30	...(*See* § 39C.)
1st Ārya Siddhānta . .	$2.147569\dot{4}$	= 2	3	32	30	= 2	8	51	15	...(*See* § 39C.)
Brāhma Siddhānta . .	2.171973	= 2	4	7	38	= 2	10	19	6	(At mean Mēsha saṁkrānti, K.Y. 1 current (Dr. Schram).
2nd Ārya Siddhānta . .	do.		do.				do.			
Siddhānta Śirōmaṇi . .	do.		do.				do.			
Original Sūrya Siddhānta .	$2.2397\dot{2}$	= 2	5	45	12	= 2	14	23	0	...(Sh. B. Dikshit.)

TABLE XXXV.

For finding the true place of Jupiter.

For parallax, the argument is the number of degrees in "V" or "Y," or the remainder after deducting "V" or "Y." from twelve signs. (*Text*, § 184A, *p.* 69.)

For equation of the centre the argument is Jupiter's anomaly.

Arg.	Parallax.	Equation of centre.	Arg.	Parallax.	Equation of centre.	Arg.	Parallax.	Equation of centre.	Arg.	Parallax.	Equation of centre.
°	° ′	° ′	°	° ′	° ′	°	° ′	° ′	°	° ′	° ′
1	0 10	0 5	46	7 8	3 35	91	11 19	5 6	136	9 9	3 41
2	0 19	0 10	47	7 17	3 38	92	11 22	5 6	137	9 0	3 37
3	0 29	0 15	48	7 25	3 42	93	11 25	5 6	138	8 51	3 33
4	0 38	0 21	49	7 33	3 45	94	11 27	5 6	139	8 41	3 29
5	0 48	0 26	50	7 41	3 48	95	11 28	5 6	140	8 32	3 25
6	0 58	0 31	51	7 48	3 52	96	11 29	5 5	141	8 22	3 21
7	1 8	0 37	52	7 56	3 56	97	11 30	5 5	142	8 12	3 17
8	1 18	0 42	53	8 4	3 59	98	11 30	5 4	143	8 2	3 13
9	1 27	0 47	54	8 12	4 2	99	11 30	5 4	144	7 52	3 8
10	1 37	0 52	55	8 20	4 5	100	11 31	5 3	145	7 41	3 4
11	1 47	0 57	56	8 27	4 8	101	11 31	5 3	146	7 31	3 0
12	1 57	1 2	57	8 34	4 11	102	11 31	5 2	147	7 19	2 55
13	2 7	1 7	58	8 41	4 14	103	11 30	5 1	148	7 8	2 50
14	2 16	1 12	59	8 48	4 17	104	11 30	5 0	149	6 57	2 46
15	2 26	1 17	60	8 55	4 20	105	11 29	4 59	150	6 46	2 41
16	2 36	1 22	61	9 1	4 22	106	11 28	4 58	151	6 34	2 36
17	2 46	1 27	62	9 8	4 25	107	11 27	4 57	152	6 23	2 31
18	2 55	1 32	63	9 14	4 27	108	11 26	4 55	153	6 11	2 27
19	3 4	1 37	64	9 21	4 30	109	11 25	4 54	154	5 59	2 22
20	3 14	1 42	65	9 28	4 32	110	11 24	4 52	155	5 47	2 17
21	3 24	1 47	66	9 34	4 35	111	11 22	4 50	156	5 34	2 12
22	3 33	1 52	67	9 40	4 37	112	11 19	4 49	157	5 21	2 7
23	3 42	1 57	68	9 45	4 39	113	11 16	4 47	158	5 8	2 2
24	3 52	2 1	69	9 49	4 41	114	11 13	4 45	159	4 55	1 57
25	4 2	2 7	70	9 54	4 43	115	11 10	4 43	160	4 42	1 51
26	4 11	2 11	71	9 59	4 45	116	11 6	4 41	161	4 29	1 46
27	4 20	2 15	72	10 4	4 47	117	11 2	4 38	162	4 16	1 41
28	4 30	2 20	73	10 9	4 49	118	10 59	4 36	163	4 2	1 35
29	4 39	2 24	74	10 14	4 51	119	10 55	4 34	164	3 48	1 30
30	4 49	2 29	75	10 19	4 52	120	10 51	4 31	165	3 34	1 24
31	4 59	2 33	76	10 24	4 54	121	10 46	4 29	166	3 20	1 19
32	5 7	2 38	77	10 28	4 55	122	10 41	4 26	167	3 6	1 13
33	5 17	2 42	78	10 33	4 56	123	10 36	4 23	168	2 52	1 8
34	5 26	2 47	79	10 37	4 57	124	10 31	4 21	169	2 38	1 2
35	5 34	2 51	80	10 41	4 59	125	10 25	4 18	170	2 24	0 57
36	5 43	2 55	81	10 46	5 0	126	10 19	4 15	171	2 10	0 51
37	5 52	2 58	82	10 50	5 1	127	10 13	4 12	172	1 55	0 45
38	6 1	3 4	83	10 54	5 1	128	10 7	4 9	173	1 41	0 40
39	6 9	3 8	84	10 58	5 2	129	10 1	4 6	174	1 27	0 34
40	6 18	3 12	85	11 1	5 3	130	9 54	4 3	175	1 13	0 29
41	6 26	3 16	86	11 4	5 4	131	9 47	3 59	176	0 59	0 24
42	6 35	3 20	87	11 7	5 4	132	9 39	3 55	177	0 44	0 18
43	6 44	3 23	88	11 10	5 5	133	9 32	3 52	178	0 29	0 12
44	6 52	3 27	89	11 13	5 5	134	9 25	3 49	179	0 15	0 6
45	7 0	3 31	90	11 16	5 5	135	9 17	3 45	180	0 0	0 0

Longitude of Jupiter's aphelion by the *Sūrya Siddhānta* = 5^{s} 21°, or 171°. The same by the *Ārya Siddhānta* = 6^{s} 0°, or 180°. Longitude of the perihelion by the *Sūrya Siddhānta* = 11^{s} 21°, or 351°. The same by the *Ārya Siddhānta* = 0^{s} 0°, or the same as the first point of Mēsha.

TABLE XXXVI.

For converting decimals of a day into hours, minutes and seconds.

First 2 decimals.	H.	M.	S.	First 2 decimals.	H.	M.	S.	3rd and 4th decimals.	M.	S.	3rd and 4th decimals.	M.	S.	5th decimal.	S.
.00	0	0	0	.50	12	0	0	.0000	0	0	.0050	7	12.00	.00000	0.000
.01	0	14	24	.51	12	14	24	01	0	8.64	51	7	20.64	1	0.864
.02	0	28	48	.52	12	28	48	02	0	17.28	52	7	29.28	2	1.728
.03	0	43	12	.53	12	43	12	03	0	25.92	53	7	37.92	3	2.592
.04	0	57	36	.54	12	57	36	04	0	34.56	54	7	46.56	4	3.456
.05	1	12	0	.55	13	12	0	05	0	43.20	55	7	55.20	5	4.320
.06	1	26	24	.56	13	26	24	06	0	51.84	56	8	3.84	6	5.184
.07	1	40	48	.57	13	40	48	07	1	0.48	57	8	12.48	7	6.048
.08	1	55	12	.58	13	55	12	08	1	9.12	58	8	21.12	8	6.912
.09	2	9	36	.59	14	9	36	09	1	17.76	59	8	29.76	9	7.776
.10	2	24	0	.60	14	24	0	10	1	26.40	60	8	38.40		
.11	2	38	24	.61	14	38	24	11	1	35.04	61	8	47.04		
.12	2	52	48	.62	14	52	48	12	1	44.08	62	8	56.08		
.13	3	7	12	.63	15	7	12	13	1	52.32	63	9	4.32		
.14	3	21	36	.64	15	21	36	14	2	1.36	64	9	12.96		
.15	3	36	0	.65	15	36	0	15	2	10.00	65	9	21.60		
.16	3	50	24	.66	15	50	24	16	2	18.24	66	9	30.24		
.17	4	4	48	.67	16	4	48	17	2	26.88	67	9	38.88		
.18	4	19	12	.68	16	19	12	18	2	35.52	68	9	47.52		
.19	4	33	36	.69	16	33	36	19	2	44.16	69	9	56.16		
.20	4	48	0	.70	16	48	0	20	2	52.80	70	10	4.80		
.21	5	2	24	.71	17	2	24	21	3	1.44	71	10	13.44		
.22	5	16	48	.72	17	16	48	22	3	10.08	72	10	22.08		
.23	5	31	12	.73	17	31	12	23	3	18.52	73	10	30.72		
.24	5	45	36	.74	17	45	36	24	3	27.36	74	10	39.36		
.25	6	0	0	.75	18	0	0	25	3	36.00	75	10	48.00		
.26	6	14	24	.76	18	14	24	26	3	44.64	76	10	56.64		
.27	6	28	48	.77	18	28	48	27	3	53.28	77	11	5.28		
.28	6	43	12	.78	18	43	12	28	4	1.92	78	11	13.92		
.29	6	57	36	.79	18	57	36	29	4	10.56	79	11	22.56		
.30	7	12	0	.80	19	12	0	30	4	19.20	80	11	31.20		
.31	7	26	24	.81	19	26	24	31	4	27.84	81	11	39.84		
.32	7	40	48	.82	19	40	48	32	4	36.48	82	11	48.48		
.33	7	55	12	.83	19	55	12	33	4	45.12	83	11	57.12		
.34	8	9	36	.84	20	9	36	34	4	53.76	84	12	5.76		
.35	8	24	0	.85	20	24	0	35	5	2.40	85	12	14.40		
.36	8	38	24	.86	20	38	24	36	5	11.04	86	12	23.04		
.37	8	52	48	.87	20	52	48	37	5	19.68	87	12	31.68		
.38	9	7	12	.88	21	7	12	38	5	28.32	88	12	40.32		
.39	9	21	36	.89	21	21	36	39	5	36.96	89	12	48.96		
.40	9	36	0	.90	21	36	0	40	5	45.60	90	12	57.60		
.41	9	50	24	.91	21	50	24	41	5	54.24	91	13	6.24		
.42	10	4	48	.92	22	4	48	42	6	2.88	92	13	14.88		
.43	10	19	12	.93	22	19	12	43	6	11.52	93	13	23.52		
.44	10	33	36	.94	22	33	36	44	6	20.16	94	13	32.16		
.45	10	48	0	.95	22	48	0	45	6	28.80	95	13	40.80		
.46	11	2	24	.96	23	2	24	46	6	37.44	96	13	49.44		
.47	11	16	48	.97	23	16	48	47	6	46.08	97	13	58.08		
.48	11	31	12	.98	23	31	12	48	6	54.72	98	14	6.72		
.49	11	45	36	.99	23	45	36	49	7	3.36	99	14	15.36		

Examples.

d.		d.	d.	h.	m.	s.
2.1	=	2.10 =	2	2	24	0
2.19	=		2	4	33	36
2.192	=	2.19 =	2	4	33	36
		.0020 =			2	52.80
		2.192 =	2	4	36	28.80
2.1921	=	2.19 =	2	4	33	36
		.0021 =			3	1.44
		2.1921 =	2	4	36	37.44

d.		d.	d.	h.	m.	s.
2.19213	=	2.19 =	2	4	33	36
		.0021 =			3	1.44
		.00003 =				2.592
		2.19213 =	2	4	36	40.032

The 6th decimal has the figure for seconds the same as the 5th, but with the decimal point moved one place to the left. The 7th has the point moved two places, the 9th four, &c.

NOTES TO TABLE XXXVII.

Col. 2. The entries are all given for the same period, *i.e.*, the mahāyuga, for the sake of comparison; but it should be noted that the *Vēdāṅga Jyōtisha* and the *Paitāmaha Siddhānta* made use of a yuga of only 5 years, the *Rōmaka* one of 2850 years, the *Pauliśa* and the *Original Sūrya* one of 180,000 years, while the *Brāhma, Parāśara,* and *Second Ārya Siddhāntas* used the Kalpa of 1000 mahāyugas; so also the *Siddhānta Śirōmaṇi* and, apparently, the *Rājamṛigāṅka*.

Col. 7. "(D)" means "calculation by the late Sh. B. Dikshit."

"(Sch.)" means "calculation by Dr. Schram."

Col. 8. The entry for the *Original Sūrya Siddhānta* was given to me by Dr. Fleet, from the *Pañchasiddhāntikā*, vv. 7, 8. I have taken those for the *Brāhma, Parāśara, Second Ārya,* and *Present Sūrya Siddhāntas,* and for the *Siddhānta Śirōmaṇi*, from the Table in Burgess and Whitney's "*Sūrya Siddhānta*," p. 27, and Jacobi's article in *Epig. Ind.*, Vol. I., pp. 440, 442, §§ 75, 83; for the *Pauliśa Siddhānta* from J. Burgess, J.R.A.S., 1893, p. 759.

Col. 9. The entry for, respectively, the *Parāśara,* and *Second Ārya Siddhāntas,* and the *Siddhānta Śirōmaṇi*, is taken from the Table in Burgess and Whitney's "*Sūrya Siddhānta*," p. 281; and for the *Brāhma Siddhānta* from Jacobi's article quoted above (with correction of a misprint).

2. *The Paitāmaha Siddhānta.* In the *Indian Calendar* (Table, p. 6) Mr. Sh. B. Dikshit and I gave the length of the solar year according to this authority as 365 d. 8 h. 34 m. Mr. D.kshit, who prepared the Table, did not show how he arrived at this figure. Dr. Fleet, however, has kindly looked into the matter for me, w.th the following result. The elements of the *Paitāmaha Siddhānta* are given by Varāhamihira in his *Pañchasiddhāntikā*, chapter 12, verses 1 to 3. The editors, Dr. Thibaut and Mahamahopadhyaya Sudhakara Dvivedi, were dealing with a manuscript which was very corrupt throughout; and in their edition (Benares, 1889) they found it necessary in verse 1 to emend *trishadyāptuṁ* into *dvishashtyā tu*. With this quite reasonable, and in fact unavoidable, emendation, the elements as given there are identical with the elements of the *Vēdāṅga Jyōtisha*, including the yuga of five years, with 366 days as the length of the solar year, with the insertion of an intercalated lunar month in thirty solar months, and with the expunction of a tithi, or lunar day, in every sixty-two tithis. The three verses in question were quoted by Bhaṭṭōtpala in his commentary below Varāhamihira's *Bṛihat Saṁhitā*, 8, 22; and in that commentary as edited by Sudhakara Dvivedi (Benares, 1895) they stand essentially as in the *Pañchasiddhāntikā* (there are only a few various readings which do not affect the meaning). But it would appear from Dikshit's *Bhāratīya Jyōtiḥśāstra*, p. 153, that he had a manuscript of Bhaṭṭōtpala's commentary with a different reading which lays down an intercalated lunar month in thirty-two (instead of thirty) solar months; that he found this reading also in Mahādēva's commentary on Śrīpati's *Ratnamālā*; that he preferred to accept the *Paitāmaha* as laying down the expunction of a tithi in every sixty-three (instead of sixty-two) tithis; and that on these two bases he arrived at the conclusion that the *Paitāmaha*, while specifying a yuga of five years, really dealt with a period of eight years measuring $2922\frac{6}{7}$ days; which gives 365 d. $21\frac{3}{7}$ gh., or 365 d. 8 h. 34 m. $17\frac{1}{7}$ s., as the length of the solar year. This conclusion is not admissible; and Dr. Fleet is of opinion that the *Paitāmaha Siddhānta* is in fact only the *Vēdāṅga Jyōtisha* under another name.

5. *The Pauliśa Siddhāntas* known to Utpala. The length of the solar year according to these was the same as that in the *Original Sūrya Siddhānta.* (*Ind. Cal., p. 6, note* 2.)

6. *The Original Sūrya Siddhānta.* For the value of the śōdhya see the end of § 39B of the text.

10. *The Second Ārya Siddhānta.* See Text, §§ 167B and 167C; and "Additional Notes," II., above, p. xii.

11. *The Rājamṛigāṅka.* I give the length of the solar year from the figures supplied by Mr. Sh. B. Dikshit in the *Indian Calendar*, p. 6. Dr. Fleet tells me that, so far as he can ascertain, no translation of this work is known, nor even a published text.

13. *The Siddhānta Śirōmaṇi.* The figures in cols. 2, 3 and 4 have been verified for me from the original text by Dr. Fleet.

General Note. The values given in cols. 5, 6, 10 have been calculated from the known values given in cols. 2, 3, 4.

TABLE XXXVII.

ELEMENTS OF THE SEVERAL SIDDHĀNTAS AS REGARDS MOTION OF SUN AND JUPITER.

Siddhāntas.	Civil days in a Mahāyuga of 4,320,000 solar years.	Length of one sidereal solar year.		Number of revolutions of Jupiter in a Mahāyuga.	Time of one sidereal revolution of Jupiter in days and decimals.
		Days and decimals.	Days, hours, mins., secs.		
1	2	3		4	5
			d. h. m. s.		
1 Vēdāṅga Jyōtisha . . .	1,581,120,000	366	366 0 0 0	—	—
2 Paitāmaha Siddhānta . . .	1,581,120,000	366	366 0 0 0	—	—
3 Rōmaka Siddhānta . . .	1,577,865,600	365.246	·365 5 55 12	—	—
4 Pauliśa Siddhānta . . .	1,577,916,000	365.2583	365 6 12 0	—	—
5 Two other "Pauliśa Siddhāntas" known to Utpala (A.D. 966) .	1,577,917,800	365.25875	365 6 12 36	—	—
6 Original Sūrya Siddhānta . .	1,577,917,800	365.25875	365 6 12 36	364,220	4332.320575476
7 First Ārya Siddhānta (A.D. 499) or Āryabhaṭīya	1,577,917,500	365.2586805	365 6 12 30	364,224	4332.272173168
8 Brāhma Siddhānta (A.D. 628) .	1,577,916,450	365.258437500	365 6 12 9	364,226.455	4332.240089479
9 Parāśara Siddhānta (mentioned in the Second Ārya Siddhānta)	1,577,917,570	365.258696736	365 6 12 31·6	—	—
10 Second Ārya Siddhānta . .	1,577,917,542	365.258690278	365 6 12 30·84	364,219.682	4332.323649659
11 Rājamrigāṅka (A.D. 1042) . .	1,577,917,546	365.258691150	365 6 12 30·915	—	—
12 Present Sūrya Siddhānta (without the bīja), Vāsishṭha Siddhānta, Śākalya-Brāhma, Present Rōmaka, Sōma Siddhāntas	1,577,917,828	365.258756481	365 6 12 36·56	364,220	4332.320652353
13 Siddhānta Śirōmaṇi (A.D. 1150)	1,577,916,450	365.258437500	365 6 12 9	364,226.455	4332.240089479
14 Present Sūrya Siddhānta with the bīja (about A.D. 1500) .	1,577,917,828	365.258756481	365 6 12 36·56	364,212	4332.415812768

TABLE XXXVII.

ELEMENTS OF THE SEVERAL SIDDHĀNTAS AS REGARDS MOTION OF SUN AND JUPITER.

	Length of one saṁvatsara of the Jovian cycle.		Śōdhya in K.Y. 1 current, 3102 B.C.		Longitude of Sun's apsis in K.Y. 1 current.	Position of Jupiter at the epoch of the Kaliyuga era.	Mean daily motion of Jupiter.
	Days and decimals.	Days, hours, mins., secs.	Days and decimals.	Days, hours, mins., secs.			
	6		7		8	9	10
		d. h. m. s.		d. h. m. s.	° ′ ″	° ′ ″	′ ″
1	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—
4	—	—	—	—	80 0 0	—	—
5	—	—	—	—	—	—	—
6	361.026714623	361 0 38 28	(D.) 2.23972	2 5 45 12	80 0 0	—	4 59.14684
7	361.022681097	361 0 32 40	(D.) 2.1475694 (Sch.) 2.146831	2 3 32 30 2 3 31 26	78 0 0	0 0 0	4 59.15018
8	361.020007456	361 0 28 49	(Sch.) 2.171973	2 4 7 38½	77 45 36	359 27 36	4 59.15240
9	—	—	—	—	77 45 36	357 2 53	—
10	361.026970805	361 0 38 50	(Sch.) 2.171972	2 4 7 38	77 45 36	357 7 12	—
11	—	—	—	—	—	—	—
12	361.026721029	361 0 38 29	(D.) 2.170694 (Sch.) 2.168900	2 4 5 48 2 4 3 13	77 7 48	0 0 0	4 59.14683
13	361.020007456	361 0 28 49	(Sch.) 2.171973	2 4 7 38½	77 45 36	359 27 36	4 59.15240
14	361.034651064	361 0 49 54	(D.) 2.170694 (Sch.) 2.168900	2 4 5 48 2 4 3 13	77 7 48	0 0 0	4 59.14206

TABLE XXXVIII.A.

TIME OF APPARENT MĒSHA SAṀKRĀNTI BY THE FIRST ĀRYA SIDDHĀNTA.
(Conforming to Table I. of the *Indian Calendar*.)

I. CONCURRENT YEAR.				III. COMMENCEMENT OF THE SOLAR YEAR.				I. CONCURRENT YEAR.				III. COMMENCEMENT OF THE SOLAR YEAR.			
Kali.	Śaka.	Chaitrādi Vikrama.	Christian Year. B.C.	Day and month A.D.	Time of apparent Mēsha saṁkrānti. Week day.	By the 1st Ārya Siddh. H.	M.	Kali.	Śaka.	Chaitrādi Vikrama.	Christian Year. B.C.	Day and month A.D.	Time of apparent Mēsha saṁkrānti. Week day.	By the 1st Ārya Siddh. H.	M.
1	2	3	5	13	14	17		1	2	3	5	13	14	17	
3044	—	—	59–58	14 Mar. (73)	5 Thur.	0	25	3082	—	38	*21–20	13 Mar. (73)	3 Tues.	20	20
3045	—	1	58–57	14 Mar. (73)	6 Fri.	6	37	3083	—	39	20–19	14 Mar. (73)	5 Thur.	2	32
3046	—	2	*57–56	13 Mar. (73)	0 Sat.	12	50	3084	—	40	19–18	14 Mar. (73)	6 Fri.	8	45
3047	—	3	56–55	13 Mar. (72)	1 Sun.	19	2	3085	—	41	18–17	14 Mar. (73)	0 Sat.	14	57
3048	—	4	55–54	14 Mar. (73)	3 Tues.	1	15	3086	—	42	*17–16	13 Mar. (73)	1 Sun.	21	10
3049	—	5	54–53	14 Mar. (73)	4 Wed.	7	27	3087	—	43	16–15	14 Mar. (73)	3 Tues.	3	22
3050	—	6	*53–52	13 Mar. (73)	5 Thur.	13	40	3088	—	44	15–14	14 Mar. (73)	4 Wed.	9	35
3051	—	7	52–51	13 Mar. (72)	6 Fri.	19	52	3089	—	45	14–13	14 Mar. (73)	5 Thur.	15	47
3052	—	8	51–50	14 Mar. (73)	1 Sun.	2	5	3090	—	46	*13–12	13 Mar. (73)	6 Fri.	22	0
3053	—	9	50–49	14 Mar. (73)	2 Mon.	8	17	3091	—	47	12–11	14 Mar. (73)	1 Sun.	4	12
3054	—	10	*49–48	13 Mar. (73)	3 Tues.	14	30	3092	—	48	11–10	14 Mar. (73)	2 Mon.	10	25
3055	—	11	48–47	13 Mar. (72)	4 Wed.	20	42	3093	—	49	10– 9	14 Mar. (73)	3 Tues.	16	37
3056	—	12	47–46	14 Mar. (73)	6 Fri.	2	55	3094	—	50	*9– 8	13 Mar. (73)	4 Wed.	22	50
3057	—	13	46–45	14 Mar. (73)	0 Sat.	9	7	3095	—	51	8– 7	14 Mar. (73)	6 Fri.	5	2
3058	—	14	*45–44	13 Mar. (73)	1 Sun.	15	20	3096	—	52	7– 6	14 Mar. (73)	0 Sat.	11	15
3059	—	15	44–43	13 Mar. (72)	2 Mon.	21	32	3097	—	53	6– 5	14 Mar. (73)	1 Sun.	17	27
3060	—	16	43–42	14 Mar. (73)	4 Wed.	3	45	3098	—	54	*5– 4	13 Mar. (73)	2 Mon.	23	40
3061	—	17	42–41	14 Mar. (73)	5 Thur.	9	57	3099	—	55	4– 3	14 Mar. (73)	4 Wed.	5	52
3062	—	18	*41–40	13 Mar. (73)	6 Fri.	16	10	3100	—	56	3– 2	14 Mar. (73)	5 Thur.	12	5
3063	—	19	40–39	13 Mar. (72)	0 Sat.	22	22	3101	—	57	2– 1	14 Mar. (73)	6 Fri.	18	17
3064	—	20	39–38	14 Mar. (73)	2 Mon.	4	35				B.C. A.D.				
3065	—	21	38–37	14 Mar. (73)	3 Tues.	10	47	3102	—	58	*1– 1	14 Mar. (74)	1 Sun.	0	30
3066	—	22	*37–36	13 Mar. (73)	4 Wed.	17	0				A.D.				
3067	—	23	36–35	13 Mar. (72)	5 Thur.	23	12	3103	—	59	1– 2	14 Mar. (73)	2 Mon.	6	42
3068	—	24	35–34	14 Mar. (73)	0 Sat.	5	25	3104	—	60	2– 3	14 Mar. (73)	3 Tues.	12	55
3069	—	25	34–33	14 Mar. (73)	1 Sun.	11	37	3105	—	61	3– 4	14 Mar. (73)	4 Wed.	19	7
3070	—	26	*33–32	13 Mar. (73)	2 Mon.	17	50	3106	—	62	*4– 5	14 Mar. (74)	6 Fri.	1	20
3071	—	27	32–31	14 Mar. (73)	4 Wed.	0	2	3107	—	63	5– 6	14 Mar. (73)	0 Sat.	7	32
3072	—	28	31–30	14 Mar. (73)	5 Thur.	6	15	3108	—	64	6– 7	14 Mar. (73)	1 Sun.	13	45
3073	—	29	30–29	14 Mar. (73)	6 Fri.	12	27	3109	—	65	7– 8	14 Mar. (73)	2 Mon.	19	57
3074	—	30	*29–28	13 Mar. (73)	0 Sat.	18	40	3110	—	66	*8– 9	14 Mar. (74)	4 Wed.	2	10
3075	—	31	28–27	14 Mar. (73)	2 Mon.	0	52	3111	—	67	9–10	14 Mar. (73)	5 Thur.	8	22
3076	—	32	27–26	14 Mar. (73)	3 Tues.	7	5	3112	—	68	10–11	14 Mar. (73)	6 Fri.	14	35
3077	—	33	26–25	14 Mar. (73)	4 Wed.	13	17	3113	—	69	11–12	14 Mar. (73)	0 Sat.	20	47
3078	—	34	*25–24	13 Mar. (73)	5 Thur.	19	30	3114	—	70	*12–13	14 Mar. (74)	2 Mon.	3	0
3079	—	35	24–23	14 Mar. (73)	0 Sat.	1	42	3115	—	71	13–14	14 Mar. (73)	3 Tues.	9	12
3080	—	36	23–22	14 Mar. (73)	1 Sun.	7	55	3116	—	72	14–15	14 Mar. (73)	4 Wed.	15	25
3081	—	37	22–21	14 Mar. (73)	2 Mon.	14	7	3117	—	73	15–16	14 Mar. (73)	5 Thur.	21	37

TABLE XXXVIII.A—*continued.*

TIME OF APPARENT MĒSHA SAṀKRĀNTI BY THE FIRST ĀRYA SIDDHĀNTA.
(Conforming to Table I. of the *Indian Calendar.*)

I. CONCURRENT YEAR.				III. COMMENCEMENT OF THE SOLAR YEAR.				I. CONCURRENT YEAR.				III. COMMENCEMENT OF THE SOLAR YEAR.			
Kali.	Śaka.	Chaitrādi Vikrama.	Christian Year. A.D.	Day and month A.D.	Time of apparent Mēsha saṁkrānti. Week day.	By the 1st Ārya Siddh. H.	M.	Kali.	Śaka.	Chaitrādi Vikrama.	Christian Year. A.D.	Day and month A.D.	Time of apparent Mēsha saṁkrānti. Week day.	By the 1st Ārya Siddh. H.	M.
1	2	3	5	13	14	17		1	2	3	5	13	14	17	
3118	—	74	*16–17	14 Mar. (74)	0 Sat.	3	50	3156	—	112	54–55	14 Mar. (73)	5 Thur.	23	45
3119	—	75	17–18	14 Mar. (73)	1 Sun.	10	2	3157	—	113	55–56	15 Mar. (74)	0 Sat.	5	57
3120	—	76	18–19	14 Mar. (73)	2 Mon.	16	15	3158	—	114	*56–57	14 Mar. (74)	1 Sun.	12	10
3121	—	77	19–20	14 Mar. (73)	3 Tues.	22	27	3159	—	115	57–58	14 Mar. (73)	2 Mon.	18	22
3122	—	78	*20–21	14 Mar. (74)	5 Thur.	4	40	3160	—	116	58–59	15 Mar. (74)	4 Wed.	0	35
3123	—	79	21–22	14 Mar. (73)	6 Fri.	10	52	3161	—	117	59–60	15 Mar. (74)	5 Thur.	6	47
3124	—	80	22–23	14 Mar. (73)	0 Sat.	17	5	3162	—	118	*60–61	14 Mar. (74)	6 Fri.	13	0
3125	—	81	23–24	14 Mar. (73)	1 Sun.	23	17	3163	—	119	61–62	14 Mar. (73)	0 Sat.	19	12
3126	—	82	*24–25	14 Mar. (74)	3 Tues.	5	30	3164	—	120	62–63	15 Mar. (74)	2 Mon.	1	25
3127	—	83	25–26	14 Mar. (73)	4 Wed.	11	42	3165	—	121	63–64	15 Mar. (74)	3 Tues.	7	37
3128	—	84	26–27	14 Mar. (73)	5 Thur.	17	55	3166	—	122	*64–65	14 Mar. (74)	4 Wed.	13	50
3129	—	85	27–28	15 Mar. (74)	0 Sat.	0	7	3167	—	123	65–66	14 Mar. (73)	5 Thur.	20	2
3130	—	86	*28–29	14 Mar. (74)	1 Sun.	6	20	3168	—	124	66–67	15 Mar. (74)	0 Sat.	2	15
3131	—	87	29–30	14 Mar. (73)	2 Mon.	12	32	3169	—	125	67–68	15 Mar. (74)	1 Sun.	8	27
3132	—	88	30–31	14 Mar. (73)	3 Tues.	18	45	3170	—	126	*68–69	14 Mar. (74)	2 Mon.	14	40
3133	—	89	31–32	15 Mar. (74)	5 Thur.	0	57	3171	—	127	69–70	14 Mar. (73)	3 Tues.	20	52
3134	—	90	*32–33	14 Mar. (74)	6 Fri.	7	10	3172	—	128	70–71	15 Mar. (74)	5 Thur.	3	5
3135	—	91	33–34	14 Mar. (73)	0 Sat.	13	22	3173	—	129	71–72	15 Mar. (74)	6 Fri.	9	17
3136	—	92	34–35	14 Mar. (73)	1 Sun.	19	35	3174	—	130	*72–73	14 Mar. (74)	0 Sat.	15	30
3137	—	93	35–36	15 Mar. (74)	3 Tues.	1	47	3175	—	131	73–74	14 Mar. (73)	1 Sun.	21	42
3138	—	94	*36–37	14 Mar. (74)	4 Wed.	8	0	3176	—	132	74–75	15 Mar. (74)	3 Tues.	3	55
3139	—	95	37–38	14 Mar. (73)	5 Thur.	14	12	3177	—	133	75–76	15 Mar. (74)	4 Wed.	10	7
3140	—	96	38–39	14 Mar. (73)	6 Fri.	20	25	3178	—	134	*76–77	14 Mar. (74)	5 Thur.	16	20
3141	—	97	39–40	15 Mar. (74)	1 Sun.	2	37	3179	—	135	77–78	14 Mar. (73)	6 Fri.	22	32
3142	—	98	*40–41	14 Mar. (74)	2 Mon.	8	50	3180	1	136	78–79	15 Mar. (74)	1 Sun.	4	45
3143	—	99	41–42	14 Mar. (73)	3 Tues.	15	2	3181	2	137	79–80	15 Mar. (74)	2 Mon.	10	57
3144	—	100	42–43	14 Mar. (73)	4 Wed.	21	15	3182	3	138	*80–81	14 Mar. (74)	3 Tues.	17	10
3145	—	101	43–44	15 Mar. (74)	6 Fri.	3	27	3183	4	139	81–82	14 Mar. (73)	4 Wed.	23	22
3146	—	102	*44–45	14 Mar. (74)	0 Sat.	9	40	3184	5	140	82–83	15 Mar. (74)	6 Fri.	5	35
3147	—	103	45–46	14 Mar. (73)	1 Sun.	15	52	3185	6	141	83–84	15 Mar. (74)	0 Sat.	11	47
3148	—	104	46–47	14 Mar. (73)	2 Mon.	22	5	3186	7	142	*84–85	14 Mar. (74)	1 Sun.	18	0
3149	—	105	47–48	15 Mar. (74)	4 Wed.	4	17	3187	8	143	85–86	15 Mar. (74)	3 Tues.	0	12
3150	—	106	*48–49	14 Mar. (74)	5 Thur.	10	30	3188	9	144	86–87	15 Mar. (74)	4 Wed.	6	25
3151	—	107	49–50	14 Mar. (73)	6 Fri.	16	42	3189	10	145	87–88	15 Mar. (74)	5 Thur.	12	37
3152	—	108	50–51	14 Mar. (73)	0 Sat.	22	55	3190	11	146	*88–89	14 Mar. (74)	6 Fri.	18	50
3153	—	109	51–52	15 Mar. (74)	2 Mon.	5	7	3191	12	147	89–90	15 Mar. (74)	1 Sun.	1	2
3154	—	110	*52–53	14 Mar. (74)	3 Tues.	11	20	3192	13	148	90–91	15 Mar. (74)	2 Mon.	7	15
3155	—	111	53–54	14 Mar. (73)	4 Wed.	17	32	3193	14	149	91–92	15 Mar. (74)	3 Tues.	13	27

TABLE XXXVIII.A—*continued.*

TIME OF APPARENT MĒSHA SAṀKRĀNTI BY THE FIRST ĀRYA SIDDHĀNTA.
(Conforming to Table I. of the *Indian Calendar.*)

I. CONCURRENT YEAR.				III. COMMENCEMENT OF THE SOLAR YEAR.			
Kali.	Śaka.	Chaitrādi Vikrama.	Christian Year. A.D.	Day and month A.D.	Time of apparent Mēsha saṁkrānti. Week day.	By the 1st Ārya Siddh. H.	M.
1	2	3	5	13	14	17	
3194	15	150	*92-93	14 Mar. (74)	4 Wed.	19	40
3195	16	151	93-94	15 Mar. (74)	6 Fri.	1	52
3196	17	152	94-95	15 Mar. (74)	0 Sat.	8	5
3197	18	153	95-96	15 Mar. (74)	1 Sun.	14	17
3198	19	154	*96-97	14 Mar. (74)	2 Mon.	20	30
3199	20	155	97-98	15 Mar. (74)	4 Wed.	2	42
3200	21	156	98-99	15 Mar. (74)	5 Thur.	8	55
3201	22	157	99-100	15 Mar. (74)	6 Fri.	15	7
3202	23	158	*100-01	14 Mar. (74)	0 Sat.	21	20
3203	24	159	101-02	15 Mar. (74)	2 Mon.	3	32
3204	25	160	102-03	15 Mar. (74)	3 Tues.	9	45
3205	26	161	103-04	15 Mar. (74)	4 Wed.	15	37
3206	27	162	*104-05	14 Mar. (74)	5 Thur.	22	10
3207	28	163	105-06	15 Mar. (74)	0 Sat.	4	22
3208	29	164	106-07	15 Mar. (74)	1 Sun.	10	35
3209	30	165	107-08	15 Mar. (74)	2 Mon.	16	47
3210	31	166	*108-09	14 Mar. (74)	3 Tues.	23	0
3211	32	167	109-10	15 Mar. (74)	5 Thur.	5	12
3212	33	168	110-11	15 Mar. (74)	6 Fri.	11	25
3213	34	169	111-12	15 Mar. (74)	0 Sat.	17	37
3214	35	170	*112-13	14 Mar. (74)	1 Sun.	23	50
3215	36	171	113-14	15 Mar. (74)	3 Tues.	6	2
3216	37	172	114-15	15 Mar. (74)	4 Wed.	12	15
3217	38	173	115-16	15 Mar. (74)	5 Thur.	18	27
3218	39	174	*116-17	15 Mar. (75)	0 Sat.	0	40
3219	40	175	117-18	15 Mar. (74)	1 Sun.	6	52
3220	41	176	118-19	15 Mar. (74)	2 Mon.	13	5
3221	42	177	119-20	15 Mar. (74)	3 Tues.	19	17
3222	43	178	*120-21	15 Mar. (75)	5 Thur.	1	30
3223	44	179	121-22	15 Mar. (74)	6 Fri.	7	42
3224	45	180	122-23	15 Mar. (74)	0 Sat.	13	55
3225	46	181	123-24	15 Mar. (74)	1 Sun.	20	7
3226	47	182	*124-25	15 Mar. (75)	3 Tues.	2	20
3227	48	183	125-26	15 Mar. (74)	4 Wed.	8	32
3228	49	184	126-27	15 Mar. (74)	5 Thur.	14	45
3229	50	185	127-28	15 Mar. (74)	6 Fri.	20	57
3230	51	186	*128-29	15 Mar. (75)	1 Sun.	3	10
3231	52	187	129-30	15 Mar. (74)	2 Mon.	9	22
3232	53	188	130-31	15 Mar. (74)	3 Tues.	15	35
3233	54	189	131-32	15 Mar. (74)	4 Wed.	21	47
3234	55	190	*132-33	15 Mar. (75)	6 Fri.	4	0
3235	56	191	133-34	15 Mar. (74)	0 Sat.	10	12
3236	57	192	134-35	15 Mar. (74)	1 Sun.	16	25
3237	58	193	135-36	15 Mar. (74)	2 Mon.	22	37
3238	59	194	*136-37	15 Mar. (75)	4 Wed.	4	50
3239	60	195	137-38	15 Mar. (74)	5 Thur.	11	2
3240	61	196	138-39	15 Mar. (74)	6 Fri.	17	15
3241	62	197	139-40	15 Mar. (74)	0 Sat.	23	27
3242	63	198	*140-41	15 Mar. (75)	2 Mon.	5	40
3243	64	199	141-42	15 Mar. (74)	3 Tues.	11	52
3244	65	200	142-43	15 Mar. (74)	4 Wed.	18	5
3245	66	201	143-44	16 Mar. (75)	6 Fri.	0	17
3246	67	202	*144-45	15 Mar. (75)	0 Sat.	6	30
3247	68	203	145-46	15 Mar. (74)	1 Sun.	12	42
3248	69	204	146-47	15 Mar. (74)	2 Mon.	18	55
3249	70	205	147-48	16 Mar. (75)	4 Wed.	1	7
3250	71	206	*148-49	15 Mar. (75)	5 Thur.	7	20
3251	72	207	149-50	15 Mar. (74)	6 Fri.	13	32
3252	73	208	150-51	15 Mar. (74)	0 Sat.	19	45
3253	74	209	151-52	16 Mar. (75)	2 Mon.	1	57
3254	75	210	*152-53	15 Mar. (75)	3 Tues.	8	10
3255	76	211	153-54	15 Mar. (74)	4 Wed.	14	22
3256	77	212	154-55	15 Mar. (74)	5 Thur.	20	35
3257	78	213	155-56	16 Mar. (75)	0 Sat.	2	47
3258	79	214	*156-57	15 Mar. (75)	1 Sun.	9	0
3259	80	215	157-58	15 Mar. (74)	2 Mon.	15	12
3260	81	216	158-59	15 Mar. (74)	3 Tues.	21	25
3261	82	217	159-60	16 Mar. (75)	5 Thur.	3	37
3262	83	218	*160-61	15 Mar. (75)	6 Fri.	9	50
3263	84	219	161-62	15 Mar. (74)	0 Sat.	16	2
3264	85	220	162-63	15 Mar. (74)	1 Sun.	22	15
3265	86	221	163-64	16 Mar. (75)	3 Tues.	4	27
3266	87	222	*164-65	15 Mar. (75)	4 Wed.	10	40
3267	88	223	165-66	15 Mar. (74)	5 Thur.	16	52
3268	89	224	166-67	15 Mar. (74)	6 Fri.	23	5
3269	90	225	167-68	16 Mar. (75)	1 Sun.	5	17

TABLE XXXVIII.A—*continued.*

Time of apparent Mēsha saṁkrānti by the First Ārya Siddhānta.

(Conforming to Table I. of the *Indian Calendar.*)

I. CONCURRENT YEAR.				III. COMMENCEMENT OF THE SOLAR YEAR.			
Kali.	Śaka.	Chaitrādi Vikrama.	Christian Year. A.D.	Day and month A.D.	Time of apparent Mēsha saṁkrānti. Week day.	By the 1st Ārya Siddh. H.	M.
1	2	3	5	13	14	17	
3270	91	226	*168–69	15 Mar. (75)	2 Mon.	11	30
3271	92	227	169–70	15 Mar. (74)	3 Tues.	17	42
3272	93	228	170–71	15 Mar. (74)	4 Wed.	23	55
3273	94	229	171–72	16 Mar. (75)	6 Fri.	6	7
3274	95	230	*172–73	15 Mar. (75)	0 Sat.	12	20
3275	96	231	173–74	15 Mar. (74)	1 Sun.	18	32
3276	97	232	174–75	16 Mar. (75)	3 Tues.	0	45
3277	98	233	175–76	16 Mar. (75)	4 Wed.	6	57
3278	99	234	*176–77	15 Mar. (75)	5 Thur.	13	10
3279	100	235	177–78	15 Mar. (74)	6 Fri.	19	22
3280	101	236	178–79	16 Mar. (75)	1 Sun.	1	35
3281	102	237	179–80	16 Mar. (75)	2 Mon.	7	47
3282	103	238	*180–81	15 Mar. (75)	3 Tues.	14	0
3283	104	239	181–82	15 Mar. (74)	4 Wed.	20	12
3284	105	240	182–83	16 Mar. (75)	6 Fri.	2	25
3285	106	241	183–84	16 Mar. (75)	0 Sat.	8	37
3286	107	242	*184–85	15 Mar. (75)	1 Sun.	14	50
3287	108	243	185–86	15 Mar. (74)	2 Mon.	21	2
3288	109	244	186–87	16 Mar. (75)	4 Wed.	3	15
3289	110	245	187–88	16 Mar. (75)	5 Thur.	9	27
3290	111	246	*188–89	15 Mar. (75)	6 Fri.	15	40
3291	112	247	189–90	15 Mar. (74)	0 Sat.	21	52
3292	113	248	190–91	16 Mar. (75)	2 Mon.	4	5
3293	114	249	191–92	16 Mar. (75)	3 Tues.	10	17
3294	115	250	*192–93	15 Mar. (75)	4 Wed.	16	30
3295	116	251	193–94	15 Mar. (74)	5 Thur.	22	42
3296	117	252	194–95	16 Mar. (75)	0 Sat.	4	55
3297	118	253	195–96	16 Mar. (75)	1 Sun.	11	7
3298	119	254	*196–97	15 Mar. (75)	2 Mon.	17	20
3299	120	255	197–98	15 Mar. (74)	3 Tues.	23	32
3300	121	256	198–99	16 Mar. (75)	5 Thur.	5	45
3301	122	257	199–200	16 Mar. (75)	6 Fri.	11	57
3302	123	258	*200–01	15 Mar. (75)	0 Sat.	18	10
3303	124	259	201–02	16 Mar. (75)	2 Mon.	0	22
3304	125	260	202–03	16 Mar. (75)	3 Tues.	6	35
3305	126	261	203–04	16 Mar. (75)	4 Wed.	12	47
3306	127	262	*204–05	15 Mar. (75)	5 Thur.	19	0
3307	128	263	205–06	16 Mar. (75)	0 Sat.	1	12

I. CONCURRENT YEAR.				III. COMMENCEMENT OF THE SOLAR YEAR.			
Kali.	Śaka.	Chaitrādi Vikrama.	Christian Year. A.D.	Day and month A.D.	Time of apparent Mēsha saṁkrānti. Week day.	By the 1st Ārya Siddh. H.	M.
1	2	3	5	13	14	17	
3308	129	264	206–07	16 Mar. (75)	1 Sun.	7	25
3309	130	265	207–08	16 Mar. (75)	2 Mon.	13	37
3310	131	266	*208–09	15 Mar. (75)	3 Tues.	19	50
3311	132	267	209–10	16 Mar. (75)	5 Thur.	2	2
3312	133	268	210–11	16 Mar. (75)	6 Fri.	8	15
3313	134	269	211–12	16 Mar. (75)	0 Sat.	14	27
3314	135	270	*212–13	15 Mar. (75)	1 Sun.	20	40
3315	136	271	213–14	16 Mar. (75)	3 Tues.	2	52
3316	137	272	214–15	16 Mar. (75)	4 Wed.	9	5
3317	138	273	215–16	16 Mar. (75)	5 Thur.	15	17
3318	139	274	*216–17	15 Mar. (75)	6 Fri.	21	30
3319	140	275	217–18	16 Mar. (75)	1 Sun.	3	42
3320	141	276	218–19	16 Mar. (75)	2 Mon.	9	55
3321	142	277	219–20	16 Mar. (75)	3 Tues.	16	7
3322	143	278	*220–21	15 Mar. (75)	4 Wed.	22	20
3323	144	279	221–22	16 Mar. (75)	6 Fri.	4	32
3324	145	280	222–23	16 Mar. (75)	0 Sat.	10	45
3325	146	281	223–24	16 Mar. (75)	1 Sun.	16	57
3326	147	282	*224–25	15 Mar. (75)	2 Mon.	23	10
3327	148	283	225–26	16 Mar. (75)	4 Wed.	5	22
3328	149	284	226–27	16 Mar. (75)	5 Thur.	11	35
3329	150	285	227–28	16 Mar. (75)	6 Fri.	17	47
3330	151	286	*228–29	16 Mar. (76)	1 Sun.	0	0
3331	152	287	229–30	16 Mar. (75)	2 Mon.	6	12
3332	153	288	230–31	16 Mar. (75)	3 Tues.	12	25
3333	154	289	231–32	16 Mar. (75)	4 Wed.	18	37
3334	155	290	*232–33	16 Mar. (76)	6 Fri.	0	50
3335	156	291	233–34	16 Mar. (75)	0 Sat.	7	2
3336	157	292	234–35	16 Mar. (75)	1 Sun.	13	15
3337	158	293	235–36	16 Mar. (75)	2 Mon.	19	27
3338	159	294	*236–37	16 Mar. (76)	4 Wed.	1	40
3339	160	295	237–38	16 Mar. (75)	5 Thur.	7	52
3340	161	296	238–39	16 Mar. (75)	6 Fri.	14	5
3341	162	297	239–40	16 Mar. (75)	0 Sat.	20	17
3342	163	298	*240–41	16 Mar. (76)	2 Mon.	2	30
3343	164	299	241–42	16 Mar. (75)	3 Tues.	8	42
3344	165	300	242–43	16 Mar. (75)	4 Wed.	14	55
3345	166	301	243–44	16 Mar. (75)	5 Thur.	21	7

TABLE XXXVIII.A—*continued.*

TIME OF APPARENT MĒSHA SAṀKRĀNTI BY THE FIRST ĀRYA SIDDHĀNTA.
(Conforming to Table I. of the *Indian Calendar*.)

I. CONCURRENT YEAR.				III. COMMENCEMENT OF THE SOLAR YEAR.			
Kali.	Saka.	Chaitrādi Vikrama.	Christian Year. A.D.	Day and month A.D.	Time of apparent Mēsha saṁkrānti. Week day.	By the 1st Ārya Siddh. H.	M.
1	2	3	5	13	14	17	
3346	167	302	*244–45	16 Mar. (76)	0 Sat.	3	20
3347	168	303	245–46	16 Mar. (75)	1 Sun.	9	32
3348	169	304	246–47	16 Mar. (75)	2 Mon.	15	45
3349	170	305	247–48	16 Mar. (75)	3 Tues.	21	57
3350	171	306	*248–49	16 Mar. (76)	5 Thur.	4	10
3351	172	307	249–50	16 Mar. (75)	6 Fri.	10	22
3352	173	308	250–51	16 Mar. (75)	0 Sat.	16	35
3353	174	309	251–52	16 Mar. (75)	1 Sun.	22	47
3354	175	310	*252–53	16 Mar. (76)	3 Tues.	5	0
3355	176	311	253–54	16 Mar. (75)	4 Wed.	11	12
3356	177	312	254–55	16 Mar. (75)	5 Thur.	17	25
3357	178	313	255–56	16 Mar. (75)	6 Fri.	23	37
3358	179	314	*256–57	16 Mar. (76)	1 Sun.	5	50
3359	180	315	257–58	16 Mar. (75)	2 Mon.	12	2
3360	181	316	258–59	16 Mar. (75)	3 Tues.	18	15
3361	182	317	259–60	17 Mar. (76)	5 Thur.	0	27
3362	183	318	*260–61	16 Mar. (76)	6 Fri.	6	40
3363	184	319	261–62	16 Mar. (75)	0 Sat.	12	52
3364	185	320	262–63	16 Mar. (75)	1 Sun.	19	5
3365	186	321	263–64	17 Mar. (76)	3 Tues.	1	17
3366	187	322	*264–65	16 Mar. (76)	4 Wed.	7	30
3367	188	323	265–66	16 Mar. (75)	5 Thur.	13	42
3368	189	324	266–67	16 Mar. (75)	6 Fri.	19	55
3369	190	325	267–68	17 Mar. (76)	1 Sun.	2	7
3370	191	326	*268–69	16 Mar. (76)	2 Mon.	8	20
3371	192	327	269–70	16 Mar. (75)	3 Tues.	14	32
3372	193	328	270–71	16 Mar. (75)	4 Wed.	20	45
3373	194	329	271–72	17 Mar. (76)	6 Fri.	2	57
3374	195	330	*272–73	16 Mar. (76)	0 Sat.	9	10
3375	196	331	273–74	16 Mar. (75)	1 Sun.	15	22
3376	197	332	274–75	16 Mar. (75)	2 Mon.	21	35
3377	198	333	275–76	17 Mar. (76)	4 Wed.	3	47
3378	199	334	*276–77	16 Mar. (76)	5 Thur.	10	0
3379	200	335	277–78	16 Mar. (75)	6 Fri.	16	12
3380	201	336	278–79	16 Mar. (75)	0 Sat.	22	25
3381	202	337	279–80	17 Mar. (76)	2 Mon.	4	37
3382	203	338	*280–81	16 Mar. (76)	3 Tues.	10	50
3383	204	339	281–82	16 Mar. (75)	4 Wed.	17	2
3384	205	340	282–83	16 Mar. (75)	5 Thur.	23	15
3385	206	341	283–84	17 Mar. (76)	0 Sat.	5	27
3386	207	342	*284–85	16 Mar. (76)	1 Sun.	11	40
3387	208	343	285–86	16 Mar. (75)	2 Mon.	17	52
3388	209	344	286–87	17 Mar. (76)	4 Wed.	0	5
3389	210	345	287–88	17 Mar. (76)	5 Thur.	6	17
3390	211	346	*288–89	16 Mar. (76)	6 Fri.	12	30
3391	212	347	289–90	16 Mar. (75)	0 Sat.	18	42
3392	213	348	290–91	17 Mar. (76)	2 Mon.	0	55
3393	214	349	291–92	17 Mar. (76)	3 Tues.	7	7
3394	215	350	*292–93	16 Mar. (76)	4 Wed.	13	20
3395	216	351	293–94	16 Mar. (75)	5 Thur.	19	32
3396	217	352	294–95	17 Mar. (76)	0 Sat.	1	45
3397	218	353	295–96	17 Mar. (76)	1 Sun.	7	57
3398	219	354	*296–97	16 Mar. (76)	2 Mon.	14	10
3399	220	355	297–98	16 Mar. (75)	3 Tues.	20	22
3400	221	356	298–99	17 Mar. (76)	5 Thur.	2	35
3401	222	357	299–300	17 Mar. (76)	6 Fri.	8	47

For later years see Table I., *Indian Calendar*.

TABLE XXXVIII.B. (IND. CAL., TABLE

I. CONCURRENT YEAR.								II. ADDED LUNAR MONTHS.				
						Saṁvatsara.		True				
									Time of the preceding saṁkrānti expressed in		Time of the succeeding saṁkrānti expressed in	
Kali.	Saka.	Chaitrādi Vikrama.	Mēshādi (solar) year in Bengal.	Kollam.	A.D.	Luni-Solar cycle. (Southern.)	Brihaspati cycle (Northern) current at Mēsha saṁkrānti.	Name of month.	Lunation parts. (t.)	Tithis.	Lunation parts. (t.)	Tithis.
1	2	3	3A	4	5	6	7	8	9	10	11	12
5003	1824	1959	1308	1076-77	1901-02	35 Plava	47 Pramādin	4 Āshāḍha	9161	27.483	3	0.009
5004	1825	1960	1309	1077-78	1902-03	36 Śubhakṛit	48 Ānanda					
5005	1826	1961	1310	1078-79	1903-04	37 Śōbhana	49 Rākshasa					
5006	1827	1962	1311	1079-80	*1904-05	38 Krōdhin	50 Anala	3 Jyēshṭha	9402	28.206	60	0.180
5007	1828	1963	1312	1080-81	1905-06	39 Viśvāvasu	51 Piṅgala					
5008	1829	1964	1313	1081-82	1906-07	40 Parābhava	52 Kālayukta					
5009	1830	1965	1314	1082-83	1907-08	41 Plavaṅga	53 Siddhārthin	1 Chaitra	9956	29.868	228	0.684
5010	1831	1966	1315	1083-84	*1908-09	42 Kīlaka	54 Raudra					
5011	1832	1967	1316	1084-85	1909-10	43 Saumya	55 Durmati	5 Śrāvaṇa	9520	28.560	159	0.477
5012	1833	1968	1317	1085-86	1910-11	44 Sādhāraṇa	56 Dundubhi					
5013	1834	1969	1318	1086-87	1911-12	45 Virōdhakṛit	57 Rudhirōdgārin					
5014	1835	1970	1319	1087-88	*1912-13	46 Paridhāvin	58 Raktāksha	4 Āshāḍha	9586	28.758	450	1.350
5015	1836	1971	1320	1088-89	1913-14	47 Pramādin	59 Krōdhana					
5016	1837	1972	1321	1089-90	1914-15	48 Ānanda	60 Kshaya					
5017	1838	1973	1322	1090-91	1915-16	49 Rākshasa	1 Prabhava	2 Vaiśākha	9714	29.142	111	0.333
5018	1839	1974	1323	1091-92	*1916-17	50 Anala	2 Vibhava					
5019	1840	1975	1324	1092-93	1917-18	51 Piṅgala	3 Śukla	6 Bhādrapada	9638	28.914	50	0.150
5020	1841	1976	1325	1093-94	1918-19	52 Kālayukta	4 Pramōda					
5021	1842	1977	1326	1094-95	1919-20	53 Siddhārthin	5 Prajāpati					
5022	1843	1978	1327	1095-96	*1920-21	54 Raudra	6 Aṅgiras	5 Śrāvaṇa	9994	29.982	769	2.307
5023	1844	1979	1328	1096-97	1921-22	55 Durmati	7 Śrīmukha					
5024	1845	1980	1329	1097-98	1922-23	56 Dundubhi	8 Bhāva					
5025	1846	1981	1330	1098-99	1923-24	57 Rudhirōdgārin	9 Yuvan	3 Jyēshṭha	9576	28.728	145	0.435
5026	1847	1982	1331	1099-1100	*1924-25	58 Raktāksha	10 Dhātṛi					
5027	1848	1983	1332	1100-01	1925-26	59 Krōdhana	11 Īśvara					

I., *continued*.)

TABLE XXXVIII.B.

III. COMMENCEMENT OF THE

Solar year.										Luni-Solar year. (Civil day of Chaitra Śukla 1st.)							Kali.
Day and month A.D.	Time of apparent Mēsha saṁkrānti.									Day and month A.D.	Week day.	At sunrise on meridian of Ujjain.					
	Week day.	By the Ārya Siddhānta.				By the Sūrya Siddhānta.						Moon's age.					
		Gh.	Pa.	H.	M.	Gh.	Pa.	H.	M.			Lunat. parts elapsed. (*t.*)	Tithis elapsed.	*a.*	*b.*	*c.*	
13	14	15		17		15A		17A		19	20	21	22	23	24	25	1
12 April (102) ..	6 Fri. ...	46	21	18	32	52	45	21	6	21 Mar. (80) ..	5 Thur. ..	177	.531	82	947	217	5003
13 April (103) ..	1 Sun. ..	1	52	0	45	8	16	3	19	9 April (99) ..	4 Wed. ..	161	.483	115	883	268	5004
13 April (103) ..	2 Mon. ..	17	24	6	57	23	48	9	31	30 Mar. (89) ..	2 Mon. ..	330	.990	329	768	241	5005
12 April (103) ..	3 Tues. ..	32	55	13	10	39	20	15	44	18 Mar. (78) ..	6 Fri. ...	258	.774	207	613	210	5006
12 April (102) ..	4 Wed. ..	48	26	19	22	54	51	21	56	5 April (95) ..	4 Wed. ..	31	. 93	9902	512	258	5007
13 April (103) ..	6 Fri. ...	3	57	1	35	10	22	4	9	25 Mar. (84) ..	1 Sun. ..	25	. 75	9778	361	227	5008
13 April (103) ..	0 Sat. ...	19	29	7	47	25	55	10	21	15 Mar. (74) ..	6 Fri.	275	.825	9992	244	199	5009
12 April (103) ..	1 Sun. ..	35	0	14	0	41	26	16	34	2 April (93) ..	5 Thur. ..	294	.882	27	179	251	5010
12 April (102) ..	2 Mon. ..	50	31	20	12	56	57	22	46	22 Mar. (81) ..	2 Mon. ..	67	.201	9902	28	220	5011
13 April (103) ..	4 Wed. ..	6	2	2	25	12	28	5	0	10 April (100) ..	1 Sun. ..	44	.132	9937	962	271	5012
13 April (103) ..	5 Thur. ..	21	34	8	37	28	1	11	12	31 Mar. (90) ..	6 Fri. ...	178	.534	152	847	243	5013
12 April (103) ..	6 Fri. ...	37	5	14	50	43	42	17	25	19 Mar. (79) ..	3 Tues. ..	38	.114	27	693	211	5014
12 April (102) ..	0 Sat. ...	52	36	21	2	59	3	23	37	7 April (97) ..	2 Mon. ..	100	.300	62	630	262	5015
13 April (103) ..	2 Mon. ..	8	7	3	15	14	34	5	50	27 Mar. (86) ..	6 Fri. ...	99	.297	9938	476	232	5016
13 April (103) ..	3 Tues. ..	23	39	9	27	30	7	12	2	16 Mar. (75) ..	3 Tues. ..	81	.243	9813	324	201	5017
12 April (103) ..	4 Wed. ..	39	10	15	40	45	38	18	15	3 April (94) ..	2 Mon. ..	128	.384	9848	260	252	5018
12 April (102) ..	5 Thur ..	54	41	21	52	†1	9	†0	27	24 Mar. (83) ..	0 Sat. ...	313	.939	63	143	224	5019
13 April (103) ..	0 Sat. ...	10	12	4	5	16	41	6	40	12 April (102) ..	6 Fri. ...	305	.915	97	79	277	5020
13 April (103) ..	1 Sun. ..	25	44	10	17	32	13	12	53	1 April (91) ..	3 Tues. ..	50	.150	9972	927	245	5021
12 April (103) ..	2 Mon. ...	41	15	16	30	47	44	19	6	21 Mar. (81) ..	1 Sun. ..	198	.594	187	809	218	5022
12 April (102) ..	3 Tues. ..	56	46	22	42	†3	15	†1	18	9 April (99) ..	0 Sat. ...	222	.666	222	746	269	5023
13 April (103) ..	5 Thur. ..	12	17	4	55	18	47	7	31	29 Mar. (88) ..	4 Wed. ..	160	.480	98	594	238	5024
13 April (103) ..	6 Fri. ...	27	49	11	7	34	19	13	43	18 Mar. (77) ..	1 Sun. ..	167	.501	9974	441	206	5025
12 April (103) ..	0 Sat. ...	43	20	17	20	49	50	19	56	5 April (96) ..	0 Sat. ...	247	.741	9	377	257	5026
12 April (102) ..	1 Sun. ..	58	51	23	32	†5	22	†2	8	25 Mar. (84) ..	4 Wed. ..	162	.486	9884	225	227	5027

† In cols. 13, 14, the day of the month and the day of the week are to be advanced by one; see footnote, Table I., *Indian Calendar*, p. liii.

TABLE XXXVIII.B.—*continued.* (IND. CAL., TABLE

I. CONCURRENT YEAR.								II. ADDED LUNAR MONTHS.				
						Saṁvatsara.		True				
Kali.	Śaka.	Chaitrādi Vikrama.	Mēshādi (solar) year in Bengal.	Kollam.	A.D.	Luni-Solar cycle. (Southern.)	Brihaspati cycle (Northern) current at Mēsha saṁkrānti.	Name of month.	Time of the preceding saṁkrānti expressed in Lunation parts. (*t.*)	Tithis.	Time of the succeeding saṁkrānti expressed in Lunation parts. (*t.*)	Tithis.
1	2	3	3A	4	5	6	7	8	9	10	11	12
5028	1849	1984	1333	1101-02	1926-27	60 Kshaya	12 Bahudhānya	1 Chaitra	9962	29.886	301	0.903
5029	1850	1985	1334	1102-03	1927-28	1 Prabhava ...	13 Pramāthin ..	....	......	....	......	....
5030	1851	1986	1335	1103-04	*1928-29	2 Vibhava	14 Vikrama ...	5 Śrāvaṇa ...	9537	28.611	285	0.855
5031	1852	1987	1336	1104-05	1929-30	3 Śukla	15 Vṛisha	....	......	....	......	....
5032	1853	1988	1337	1105-06	1930-31	4 Pramōda ...	16 Chitrabhānu	....	......	....	......	....
5033	1854	1989	1338	1106-07	1931-32	5 Prajāpati ...	17 Subhānu ...	4 Āshāḍha ..	9638	28.914	420	1.260
5034	1855	1990	1339	1107-08	*1932-33	6 Aṅgiras	18 Tāraṇa	....	......	....	......	....
5035	1856	1991	1340	1108-09	1933-34	7 Śrīmukha ...	19 Pārthiva ...	....	......	....	......	....
5036	1857	1992	1341	1109-10	1934-35	8 Bhāva	20 Vyaya	2 Vaiśākha...	9820	29.460	288	0.864
5037	1858	1993	1342	1110-11	1935-36	9 Yuvan	21 Sarvajit	....	......	....	......	....
5038	1859	1994	1343	1111-12	*1936-37	10 Dhātṛi	22 Sarvadhārin	6 Bhādrapada	9789	29.367	246	0.738
5039	1860	1995	1344	1112-13	1937-38	11 Īśvara	23 Virōdhin ...	....	......	....	......	....
5040	1861	1996	1345	1113-14	1938-39	12 Bahudhānya	24 Vikṛita	....	......	....	......	....
5041	1862	1997	1346	1114-15	1939-40	13 Pramāthin ..	25 Khara	5 Śrāvaṇa ...	9956	29.868	765	2.295
5042	1863	1998	1347	1115-16	*1940-41	14 Vikrama ...	26 Nandana ...	....	......	....	......	....
5043	1864	1999	1348	1116-17	1941-42	15 Vṛisha	27 Vijaya	....	......	....	......	....
5044	1865	2000	1349	1117-18	1942-43	16 Chitrabhānu	28 Jaya [1]	3 Jyēshṭha ..	9769	29.307	320	0.960
5045	1866	2001	1350	1118-19	1943-44	17 Subhānu ...	30 Durmukha ..	....	......	....	......	....
5046	1867	2002	1351	1119-20	*1944-45	18 Tāraṇa	31 Hēmalamba	....	......	....	......	....
5047	1868	2003	1352	1120-21	1945-46	19 Pārthiva ...	32 Vilamba ...	1 Chaitra	9919	29.757	283	0.849
5048	1869	2004	1353	1121-22	1946-47	20 Vyaya	33 Vikārin	....	......	....	......	....
5049	1870	2005	1354	1122-23	1947-48	21 Sarvajit	34 Śārvarin	5 Śrāvaṇa ...	9495	28.485	304	0.912
5050	1871	2006	1355	1123-24	*1948-49	22 Sarvadhārin	35 Plava	....	......	....	......	....
5051	1872	2007	1356	1124-25	1949-50	23 Virōdhin ...	36 Śubhakṛit ..	....	......	....	......	....
5052	1873	2008	1357	1125-26	1950-51	24 Vikṛita	37 Śōbhana ...	4 Āshāḍha ..	9788	29.364	464	1.392

(1) 29 Manmatha was suppressed in the north.

I., *continued.*)

TABLE XXXVIII.B.—*continued.*

III. COMMENCEMENT OF THE

Solar year. Day and month A.D.	Solar year. Time of apparent Mēsha saṁkrānti. Week day.	By the Ārya Siddhānta. Gh.	By the Ārya Siddhānta. Pa.	By the Ārya Siddhānta. H.	By the Ārya Siddhānta. M.	By the Sūrya Siddhānta. Gh.	By the Sūrya Siddhānta. Pa.	By the Sūrya Siddhānta. H.	By the Sūrya Siddhānta. M.	Luni-Solar year. (Civil day of Chaitra Śukla 1st.) Day and month A.D.	Week day.	At sunrise on the meridian of Ujjain. Moon's age. Lunat. parts elapsed. (*t.*)	Tithis elapsed.	*a.*	*b.*	*c.*	Kali.
13	14	15		17		15A		17A		19	20	21	22	23	24	25	1
13 April (103) ..	3 Tues. ..	14	22	5	45	20	53	8	21	15 Mar. (74) . . .	2 Mon. . . .	331	.993	99	108	199	5028
13 April (103) ..	4 Wed. ..	29	54	11	57	36	25	14	33	3 April (93). . .	1 Sun. ..	312	.936	133	44	250	5029
12 April (103) ..	5 Thur. ..	45	25	18	10	51	56	20	47	22 Mar. (82) ..	5 Thur. ..	60	.180	8	892	219	5030
13 April (103) ..	0 Sat. . . .	0	56	0	22	7	28	2	59	10 April (100) ..	4 Wed. ..	59	.177	43	828	271	5031
13 April (103) ..	1 Sun. ..	16	27	6	35	22	59	9	12	31 Mar. (90) ..	2 Mon. ..	261	.783	257	711	242	5032
13 April (103) ..	2 Mon. ..	31	59	12	47	38	31	15	24	20 Mar. (79) ..	6 Fri. . . .	225	.675	133	558	211	5033
12 April (103) ..	3 Tues. ..	47	30	19	0	54	2	21	37	7 April (98) ..	5 Thur. .	312	.936	167	495	262	5034
13 April (103) ..	5 Thur. .	3	1	1	12	9	34	3	49	27 Mar. (86) ..	2 Mon. ..	301	.903	43	341	231	5035
13 April (103) ..	6 Fri. . . .	18	32	7	25	25	5	10	2	16 Mar. (75) ..	6 Fri. . . .	193	.579	9920	189	201	5036
13 April (103) ..	0 Sat. . . .	34	4	13	37	40	37	16	14	4 April (94) ..	5 Thur. .	192	.576	9954	124	251	5037
12 April (103) ..	1 Sun. ..	49	35	19	50	56	8	22	27	24 Mar. (84) ..	3 Tues. ..	316	.948	169	7	224	5038
13 April (103) ..	3 Tues. ..	5	6	2	2	11	40	4	40	12 April (102) ..	2 Mon. ..	294	.882	202	944	275	5039
13 April (103) ..	4 Wed. ..	20	37	8	15	27	11	10	53	1 April (91) ..	6 Fri. . . .	83	.249	79	790	244	5040
13 April (103) ..	5 Thur. ..	36	9	14	27	42	43	17	5	22 Mar. (81) ..	4 Wed. ..	310	.930	293	673	217	5041
12 April (103) ..	6 Fri. . . .	51	40	20	40	58	15	23	18	8 April (99) ..	2 Mon. ..	67	.201	9989	574	265	5042
13 April (103) ..	1 Sun. ..	7	11	2	52	13	46	5	30	28 Mar. (87) ..	6 Fri. . . .	73	.219	9865	420	233	5043
13 April (103) ..	2 Mon. ..	22	42	9	5	29	17	11	43	17 Mar. (76) ..	3 Tues. ..	22	.066	9740	268	203	5044
13 April (103) ..	3 Tues. ..	38	14	15	17	44	49	17	55	5 April (95) . . .	2 Mon. ..	49	.147	9775	204	255	5045
12 April (103) ..	4 Wed. ..	53	45	21	30	†0	21	†0	8	25 Mar. (85) ..	0 Sat. . . .	203	.609	9989	88	227	5046
13 April (103) ..	6 Fri. . . .	9	16	3	42	15	52	6	20	15 Mar. (74) . . .	5 Thur. ..	323	.969	205	971	200	5047
13 April (103) ..	0 Sat. . . .	24	47	9	55	31	23	12	34	3 April (93) ..	4 Wed. ..	301	.903	238	907	250	5048
13 April (103) ..	1 Sun. ..	40	19	16	7	46	56	18	46	23 Mar. (82) ..	1 Sun. ..	115	.345	114	754	220	5049
12 April (103) ..	2 Mon. ..	55	50	22	20	†2	27	†0	59	10 April (101) ..	0 Sat. . . .	159	.477	149	689	271	5050
13 April (103) ..	4 Wed. ..	11	21	4	32	17	58	7	11	30 Mar. (89) ..	4 Wed. ..	131	.393	24	538	240	5051
13 April (103) ..	5 Thur. .	26	52	10	45	33	29	13	24	19 Mar. (78) ..	1 Sun. ..	135	.405	9900	385	209	5052

† In cols. 13, 14, the day of the month and the day of the week are to be advanced by one; see footnote, Table I., *Indian Calendar*, p. liii.

TABLE XXXVIII.C.

The time of mean Mēsha saṁkrānti by the Ārya Siddhānta from A.D. 499 to 1075.

Seeing that in many of the calculations necessary for the verification of Indian dates the moment of occurrence of mean Mēsha saṁkrānti according to the *First Ārya Siddhānta* has to be ascertained; and since in the text (*Example* 5) I have advised that this moment be found, first, by taking from the *Indian Calendar*, Table I. (or finding), the moment of true or apparent Mēsha saṁkrānti, and, secondly, by adding to this the amount of the *Ārya Siddhānta* śōdhya taken as a constant, which addition gives the moment of mean Mēsha saṁkrānti by that authority—I have now thought it advisable to still further save trouble to calculators by giving a Table which at once yields the moment of mean Mēsha saṁkrānti for a period of 576 years.

I take the period A.D. 499 to 1075 because it is certain that the moment of mean Mēsha saṁkrānti in A.D. 499 was exactly at 6 h. 0 m. Laṅkā time, or exactly at noon, on March 21st in that year (§ 162 *above*); and this fact provides a sure basis from which to work. Also because both the *Original Sūrya Siddhānta* and the *First Ārya Siddhānta* were at that moment in exact coincidence, which they were at no other time. Starting from that point, the subsequent figures are obtained by adding 6 h. 12.5 m. annually: this is composed of 12.5 m., the time by which the length of the solar year of the *First Ārya Siddhānta* exceeds that of the Julian year, plus the 6 h. which in the Julian calendar are only brought to account in each fourth year; and 24 h. are, of course, retrenched from col. 5 and are added in cols. 2, 3, 4, whenever the accumulation of the annual additive amount passes from below to above one complete day.

The number of years for which the Table is given, viz.: 576, is chosen because, with these moments of mean Mēsha saṁkrānti fixed for such a period, which covers exactly what we may style a cycle of the Mēsha saṁkrānti according to this work, it is easy to ascertain the similar moment of any year, earlier or later than the period so covered. The rules given for apparent Mēsha saṁkrāntis in §§ 47 to 51 apply equally to mean Mēsha saṁkrāntis when the time of the latter is known.

Example. By the Table, mean Mēsha saṁkrānti of A.D. 499 took place on (1) Sunday, March 21st, at 6 h. 0 m. By the rule given in § 54, mean Mēsha saṁkrānti of (499 + 576 =) A.D. 1075 took place on (1 + 4 =) 5 Thursday (21 + 5 =) March 26th at 6 h. 0 m., and this is the entry for that year given in the Table. Similarly, mean Mēsha saṁkrānti of 78 B.C. (§ 50, 577 — 499) took place at 6 h. 0 m. on (1, or 8, — 4 =) 4 Wednesday, March 16th (21 — 5).

From this Table we can also determine the apparent Mēsha saṁkrānti for any desired year according to the *Ārya Siddhānta.* Having found the moment of mean Mēsha saṁkrānti by the Table, or as shown in the example, deduct the śōdhya, viz.: 2 d. 3 h. 32.5 m. The result is the moment of apparent Mēsha saṁkrānti. If the time is wanted according to Dr. Schram's valuation of the śōdhya, add 1 m. 4 s. to the (mean or true) final result.

TABLE XXXVIII.C.

TIME OF MEAN MĒSHA SAṀKRĀNTI BY THE ĀRYA SIDDHĀNTA, A.D. 499 TO 1075.

NOTE.—*In working backwards or forwards with this Table, it is useful to bear in mind that (for instance) March 21st may be expressed as " 49 February," or " 50 February " in a Leap-year. " 36 March " would mean April 5th ; and so on.*

Cols. 1, 2, 4, 5 give the European year, day of the month, week-day, and time of occurrence, *i.e.*, hour and minute, of mean Mēsha saṁkrānti, in Laṅkā time. Col. 3 shows the serial number of the day, measured from January 1st as 1, in conformity with Table IX. of the *Indian Calendar*.

A.D.	Day in March.	Day of year.	Week-day " w."	Laṅkā time. H.	M.	A.D.	Day in March.	Day of year.	Week-day " w."	Laṅkā time. H.	M.	A.D.	Day in March.	Day of year.	Week-day " w."	Laṅkā time. H.	M.	A.D.	Day in March.	Day of year.	Week-day " w."	Laṅkā time. H.	M.
1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5	
499	21	80	1	6	0	*540	20	80	3	20	32.5	581	21	80	6	11	5	622	22	81	2	1	37.5
*500	20	80	2	12	12.5	541	21	80	5	2	45	582	21	80	0	17	17.5	623	22	81	3	7	50
501	20	79	3	18	25	542	21	80	6	8	57.5	583	21	80	1	23	30	*624	21	81	4	14	2.5
502	21	80	5	0	37.5	543	21	80	0	15	10	*584	21	81	3	5	42.5	625	21	80	5	20	15
503	21	80	6	6	50	*544	20	80	1	21	22.5	585	21	80	4	11	55	626	22	81	0	2	27.5
*504	20	80	0	13	2.5	545	21	80	3	3	35	586	21	80	5	18	7.5	627	22	81	1	8	40
505	20	79	1	19	15	546	21	80	4	9	47.5	587	22	81	0	0	20	*628	21	81	2	14	52.5
506	21	80	3	1	27.5	547	21	80	5	16	0	*588	21	81	1	6	32.5	629	21	80	3	21	5
507	21	80	4	7	40	*548	20	80	6	22	12.5	589	21	80	2	12	45	630	22	81	5	3	17.5
*508	20	80	5	13	52.5	549	21	80	1	4	25	590	21	80	3	18	57.5	631	22	81	6	9	30
509	20	79	6	20	5	550	21	80	2	10	37.5	591	22	81	5	1	10	*632	21	81	0	15	42.5
510	21	80	1	2	17.5	551	21	80	3	16	50	*592	21	81	6	7	22.5	633	21	80	1	21	55
511	21	80	2	8	30	*552	20	80	4	23	2.5	593	21	80	0	13	35	634	22	81	3	4	7.5
*512	20	80	3	14	42.5	553	21	80	6	5	15	594	21	80	1	19	47.5	635	22	81	4	10	20
513	20	79	4	20	55	554	21	80	0	11	27.5	595	22	81	3	2	0	*636	21	81	5	16	32.5
514	21	80	6	3	7.5	555	21	80	1	17	40	*596	21	81	4	8	12.5	637	21	80	6	22	45
515	21	80	0	9	20	*556	20	80	2	23	52.5	597	21	80	5	14	25	638	22	81	1	4	57.5
*516	20	80	1	15	32.5	557	21	80	4	6	5	598	21	80	6	20	37.5	639	22	81	2	11	10
517	20	79	2	21	45	558	21	80	5	12	17.5	599	22	81	1	2	50	*640	21	81	3	17	22.5
518	21	80	4	3	57.5	559	21	80	6	18	30	*600	21	81	2	9	2.5	641	21	80	4	23	35
519	21	80	5	10	10	*560	21	81	1	0	42.5	601	21	80	3	15	15	642	22	81	6	5	47.5
*520	20	80	6	16	22.5	561	21	80	2	6	55	602	21	80	4	21	27.5	643	22	81	0	12	0
521	20	79	0	22	35	562	21	80	3	13	7.5	603	22	81	6	3	40	*644	21	81	1	18	12.5
522	21	80	2	4	47.5	563	21	80	4	19	20	*604	21	81	0	9	52.5	645	22	81	3	0	25
523	21	80	3	11	0	*564	21	81	6	1	32.5	605	21	80	1	16	5	646	22	81	4	6	37.5
*524	20	80	4	17	12.5	565	21	80	0	7	45	606	21	80	2	22	17.5	647	22	81	5	12	50
525	20	79	5	23	25	566	21	80	1	13	57.5	607	22	81	4	4	30	*648	21	81	6	19	2.5
526	21	80	0	5	37.5	567	21	80	2	20	10	*608	21	81	5	10	42.5	649	22	81	1	1	15
527	21	80	1	11	50	*568	21	81	4	2	22.5	609	21	80	6	16	55	650	22	81	2	7	27.5
*528	20	80	2	18	2.5	569	21	80	5	8	35	610	21	80	0	23	7.5	651	22	81	3	13	40
529	21	80	4	0	15	570	21	80	6	14	47.5	611	22	81	2	5	20	*652	21	81	4	19	52.5
530	21	80	5	6	27.5	571	21	80	0	21	0	*612	21	81	3	11	32.5	653	22	81	6	2	5
531	21	80	6	12	40	*572	21	81	2	3	12.5	613	21	80	4	17	45	654	22	81	0	8	17.5
*532	20	80	0	18	52.5	573	21	80	3	9	25	614	21	80	5	23	57.5	655	22	81	1	14	30
533	21	80	2	1	5	574	21	80	4	15	37.5	615	22	81	0	6	10	*656	21	81	2	20	42.5
534	21	80	3	7	17.5	575	21	80	5	21	50	*616	21	81	1	12	22.5	657	22	81	4	2	55
535	21	80	4	13	30	*576	21	81	0	4	2.5	617	21	80	2	18	35	658	22	81	5	9	7.5
*536	20	80	5	19	42.5	577	21	80	1	10	15	618	22	81	4	0	47.5	659	22	81	6	15	20
537	21	80	0	1	55	578	21	80	2	16	27.5	619	22	81	5	7	0	*660	21	81	0	21	32.5
538	21	80	1	8	7.5	579	21	80	3	22	40	*620	21	81	6	13	12.5	661	22	81	2	3	45
539	21	80	2	14	20	*580	21	81	5	4	52.5	621	21	80	0	19	25	662	22	81	3	9	57.5

TABLE XXXVIII.C—*continued.*

A.D.	Day in March.	Day of year.	Week-day "w."	Lankā time. H.	M.	A.D.	Day in March.	Day of year.	Week-day "w."	Lankā time. H.	M.	A.D.	Day in March.	Day of year.	Week-day "w."	Lankā time. H.	M.	A.D.	Day in March.	Day of year.	Week-day "w."	Lankā time. H.	M.
1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5	
663	22	81	4	16	10	715	23	82	0	3	0	767	23	82	2	13	50	819	24	83	5	0	40
*664	21	81	5	22	22.5	*716	22	82	1	9	12.5	*768	22	82	3	20	2.5	*820	23	83	6	6	52.5
665	22	81	0	4	35	717	22	81	2	15	25	769	23	82	5	2	15	821	23	82	0	13	5
666	22	81	1	10	47.5	718	22	81	3	21	37.5	770	23	82	6	8	27.5	822	23	82	1	19	17.5
667	22	81	2	17	0	719	23	82	5	3	50	771	23	82	0	14	40	823	24	83	3	1	30
*668	21	81	3	23	12.5	*720	22	82	6	10	2.5	*772	22	82	1	20	52.5	*824	23	83	4	7	42.5
669	22	81	5	5	25	721	22	81	0	16	15	773	23	82	3	3	5	825	23	82	5	13	55
670	22	81	6	11	37.5	722	22	81	1	22	27.5	774	23	82	4	9	17.5	826	23	82	6	20	7.5
671	22	81	0	17	50	723	23	82	3	4	40	775	23	82	5	15	30	827	24	83	1	2	20
*672	22	82	2	0	2.5	*724	22	82	4	10	52.5	*776	22	82	6	21	42.5	*828	23	83	2	8	32.5
673	22	81	3	6	15	725	22	81	5	17	5	777	23	82	1	3	55	829	23	82	3	14	45
674	22	81	4	12	27.5	726	22	81	6	23	17.5	778	23	82	2	10	7.5	830	23	82	4	20	57.5
675	22	81	5	18	40	727	23	82	1	5	30	779	23	82	3	16	20	831	24	83	6	3	10
*676	22	82	0	0	52.5	*728	22	82	2	11	42.5	*780	22	82	4	22	32.5	*832	23	83	0	9	22.5
677	22	81	1	7	5	729	22	81	3	17	55	781	23	82	6	4	45	833	23	82	1	15	35
678	22	81	2	13	17.5	730	23	82	5	0	7.5	782	23	82	0	10	57.5	834	23	82	2	21	47.5
679	22	81	3	19	30	731	23	82	6	6	20	783	23	82	1	17	10	835	24	83	4	4	0
*680	22	82	5	1	42.5	*732	22	82	0	12	32.5	*784	22	82	2	23	22.5	*836	23	83	5	10	12.5
681	22	81	6	7	55	733	22	81	1	18	45	785	23	82	4	5	35	837	23	82	6	16	25
682	22	81	0	14	7.5	734	23	82	3	0	57.5	786	23	82	5	11	47.5	838	23	82	0	22	37.5
683	22	81	1	20	20	735	23	82	4	7	10	787	23	82	6	18	0	839	24	83	2	4	50
*684	22	82	3	2	32.5	*736	22	82	5	13	22.5	*788	23	83	1	0	12.5	*840	23	83	3	11	2.5
685	22	81	4	8	45	737	22	81	6	19	35	789	23	82	2	6	25	841	23	82	4	17	15
686	22	81	5	14	57.5	738	23	82	1	1	47.5	790	23	82	3	12	37.5	842	23	82	5	23	27.5
687	22	81	6	21	10	739	23	82	2	8	0	791	23	82	4	18	50	843	24	83	0	5	40
*688	22	82	1	3	22.5	*740	22	82	3	14	12.5	*792	23	83	6	1	2.5	*844	23	83	1	11	52.5
689	22	81	2	9	35	741	22	81	4	20	25	793	23	82	0	7	15	845	23	82	2	18	5
690	22	81	3	15	47.5	742	23	82	6	2	37.5	794	23	82	1	13	27.5	846	24	83	4	0	17.5
691	22	81	4	22	0	743	23	82	0	8	50	795	23	82	2	19	40	847	24	83	5	6	30
*692	22	82	6	4	12.5	*744	22	82	1	15	2.5	*796	23	83	4	1	52.5	*848	23	83	6	12	42.5
693	22	81	0	10	25	745	22	81	2	21	15	797	23	82	5	8	5	849	23	82	0	18	55
694	22	81	1	16	37.5	746	23	82	4	3	27.5	798	23	82	6	14	17.5	850	24	83	2	1	7.5
695	22	81	2	22	50	747	23	82	5	9	40	799	23	82	0	20	30	851	24	83	3	7	20
*696	22	82	4	5	2.5	*748	22	82	6	15	52.5	*800	23	83	2	2	42.5	*852	23	83	4	13	32.5
697	22	81	5	11	15	749	22	81	0	22	5	801	23	82	3	8	55	853	23	82	5	19	45
698	22	81	6	17	27.5	750	23	82	2	4	17.5	802	23	82	4	15	7.5	854	24	83	0	1	57.5
699	22	81	0	23	40	751	23	82	3	10	30	803	23	82	5	21	20	855	24	83	1	8	10
*700	22	82	2	5	52.5	*752	22	82	4	16	42.5	*804	23	83	0	3	32.5	*856	23	83	2	14	22.5
701	22	81	3	12	5	753	22	81	5	22	55	805	23	82	1	9	45	857	23	82	3	20	35
702	22	81	4	18	17.5	754	23	82	0	5	7.5	806	23	82	2	15	57.5	858	24	83	5	2	47.5
703	23	82	6	0	30	755	23	82	1	11	20	807	23	82	3	22	10	859	24	83	6	9	0
*704	22	82	0	6	42.5	*756	22	82	2	17	32.5	*808	23	83	5	4	22.5	*860	23	83	0	15	12.5
705	22	81	1	12	55	757	22	81	3	23	45	809	23	82	6	10	35	861	23	82	1	21	25
706	22	81	2	19	7.5	758	23	82	5	5	57.5	810	23	82	0	16	47.5	862	24	83	3	3	37.5
707	23	82	4	1	20	759	23	82	6	12	10	811	23	82	1	23	0	863	24	83	4	9	50
*708	22	82	5	7	32.5	*760	22	82	0	18	22.5	*812	23	83	3	5	12.5	*864	23	83	5	16	2.5
709	22	81	6	13	45	761	23	82	2	0	35	813	23	82	4	11	25	865	23	82	6	22	15
710	22	81	0	19	57.5	762	23	82	3	6	47.5	814	23	82	5	17	37.5	866	24	83	1	4	27.5
711	23	82	2	2	10	763	23	82	4	13	0	815	23	82	6	23	50	867	24	83	2	10	40
*712	22	82	3	8	22.5	*764	22	82	5	19	12.5	*816	23	83	1	6	2.5	*868	23	83	3	16	52.5
713	22	81	4	14	35	765	23	82	0	1	25	817	23	82	2	12	15	869	23	82	4	23	5
714	22	81	5	20	47.5	766	23	82	1	7	37.5	818	23	82	3	18	27.5	870	24	83	6	5	17.5

TABLE XXXVIII.C—*continued.*

A.D.	Day in March.	Day of year.	Week-day "w."	Lankā time. H.	M.	A.D.	Day in March.	Day of year.	Week-day "w."	Lankā time. H.	M.	A.D.	Day in March.	Day of year.	Week-day "w."	Lankā time. H.	M.	A.D.	Day in March.	Day of year.	Week-day "w."	Lankā time. H.	M.
1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5	
871	24	83	0	11	30	923	24	83	2	22	20	974	25	84	4	2	57.5	1025	25	84	5	7	35
*872	23	83	1	17	42.5	*924	24	84	4	4	32.5	975	25	84	5	9	10	1026	25	84	6	13	47.5
873	23	82	2	23	55	925	24	83	5	10	45	*976	24	84	6	15	22.5	1027	25	84	0	20	0
874	24	83	4	6	7.5	926	24	83	6	16	57.5	977	24	83	0	21	35	*1028	25	85	2	2	12.5
875	24	83	5	12	20	927	24	83	0	23	10	978	25	84	2	3	47.5	1029	25	84	3	8	25
*876	23	83	6	18	32.5	*928	24	84	2	5	22.5	979	25	84	3	10	0	1030	25	84	4	14	37.5
877	24	83	1	0	45	929	24	83	3	11	35	*980	24	84	4	16	12.5	1031	25	84	5	20	50
878	24	83	2	6	57.5	930	24	83	4	17	47.5	981	24	83	5	22	25	*1032	25	85	0	3	2.5
879	24	83	3	13	10	931	25	84	6	0	0	982	25	84	0	4	37.5	1033	25	84	1	9	15
*880	23	83	4	19	22.5	*932	24	84	0	6	12.5	983	25	84	1	10	50	1034	25	84	2	15	27.5
881	24	83	6	1	35	933	24	83	1	12	25	*984	24	84	2	17	2.5	1035	25	84	3	21	40
882	24	83	0	7	47.5	934	24	83	2	18	37.5	985	24	83	3	23	15	*1036	25	85	5	3	52.5
883	24	83	1	14	0	935	25	84	4	0	50	986	25	84	5	5	27.5	1037	25	84	6	10	5
*884	23	83	2	20	12.5	*936	24	84	5	7	2.5	987	25	84	6	11	40	1038	25	84	0	16	17.5
885	24	83	4	2	25	937	24	83	6	13	15	*988	24	84	0	17	52.5	1039	25	84	1	22	30
886	24	83	5	8	37.5	938	24	83	0	19	27.5	989	25	84	2	0	5	*1040	25	85	3	4	42.5
887	24	83	6	14	50	939	25	84	2	1	40	990	25	84	3	6	17.5	1041	25	84	4	10	55
*888	23	83	0	21	2.5	*940	24	84	3	7	52.5	991	25	84	4	12	30	1042	25	84	5	17	7.5
889	24	83	2	3	15	941	24	83	4	14	5	*992	24	84	5	18	42.5	1043	25	84	6	23	20
890	24	83	3	9	27.5	942	24	83	5	20	17.5	993	25	84	0	0	55	*1044	25	85	1	5	32.5
891	24	83	4	15	40	943	25	84	0	2	30	994	25	84	1	7	7.5	1045	25	84	2	11	45
*892	23	83	5	21	52.5	*944	24	84	1	8	42.5	995	25	84	2	13	20	1046	25	84	3	17	57.5
893	24	83	0	4	5	945	24	83	2	14	55	*996	24	84	3	19	32.5	1047	26	85	5	0	10
894	24	83	1	10	17.5	946	24	83	3	21	7.5	997	25	84	5	1	45	*1048	25	85	6	6	22.5
895	24	83	2	16	30	947	25	84	5	3	20	998	25	84	6	7	57.5	1049	25	84	0	12	35
*896	23	83	3	22	42.5	*948	24	84	6	9	32.5	999	25	84	0	14	10	1050	25	84	1	18	47.5
897	24	83	5	4	55	949	24	83	0	15	45	*1000	24	84	1	20	22.5	1051	26	85	3	1	0
898	24	83	6	11	7.5	950	24	83	1	21	57.5	1001	25	84	3	2	35	*1052	25	85	4	7	12.5
899	24	83	0	17	20	951	25	84	3	4	10	1002	25	84	4	8	47.5	1053	25	84	5	13	25
*900	23	83	1	23	32.5	*952	24	84	4	10	22.5	1003	25	84	5	15	0	1054	25	84	6	19	37.5
901	24	83	3	5	45	953	24	83	5	16	35	*1004	24	84	6	21	12.5	1055	26	85	1	1	50
902	24	83	4	11	57.5	954	24	83	6	22	47.5	1005	25	84	1	3	25	*1056	25	85	2	8	2.5
903	24	83	5	18	10	955	25	84	1	5	0	1006	25	84	2	9	37.5	1057	25	84	3	14	15
*904	24	84	0	0	22.5	*956	24	84	2	11	12.5	1007	25	84	3	15	50	1058	25	84	4	20	27.5
905	24	83	1	6	35	957	24	83	3	17	25	*1008	24	84	4	22	2.5	1059	26	85	6	2	40
906	24	83	2	12	47.5	958	24	83	4	23	37.5	1009	25	84	6	4	15	*1060	25	85	0	8	52.5
907	24	83	3	19	0	959	25	84	6	5	50	1010	25	84	0	10	27.5	1061	25	84	1	15	5
*908	24	84	5	1	12.5	*960	24	84	0	12	2.5	1011	25	84	1	16	40	1062	25	84	2	21	17.5
909	24	83	6	7	25	961	24	83	1	18	15	*1012	24	84	2	22	52.5	1063	26	85	4	3	30
910	24	83	0	13	37.5	962	25	84	3	0	27.5	1013	25	84	4	5	5	*1064	25	85	5	9	42.5
911	24	83	1	19	50	963	25	84	4	6	40	1014	25	84	5	11	17.5	1065	25	84	6	15	55
*912	24	84	3	2	2.5	*964	24	84	5	12	52.5	1015	25	84	6	17	30	1066	25	84	0	22	7.5
913	24	83	4	8	15	965	24	83	6	19	5	*1016	24	84	0	23	42.5	1067	26	85	2	4	20
914	24	83	5	14	27.5	966	25	84	1	1	17.5	1017	25	84	2	5	55	*1068	25	85	3	10	32.5
915	24	83	6	20	40	967	25	84	2	7	30	1018	25	84	3	12	7.5	1069	25	84	4	16	45
*916	24	84	1	2	52.5	*968	24	84	3	13	42.5	1019	25	84	4	18	20	1070	25	84	5	22	57.5
917	24	83	2	9	5	969	24	83	4	19	55	*1020	25	85	6	0	32.5	1071	26	85	0	5	10
918	24	83	3	15	17.5	970	25	84	6	2	7.5	1021	25	84	0	6	45	*1072	25	85	1	11	22.5
919	24	83	4	21	30	971	25	84	0	8	20	1022	25	84	1	12	57.5	1073	25	84	2	17	35
*920	24	84	6	3	42.5	*972	24	84	1	14	32.5	1023	25	84	2	19	10	1074	25	84	3	23	47.5
921	24	83	0	9	55	973	24	83	2	20	45	*1024	25	85	4	1	22.5	1075	26	85	5	6	0
922	24	83	1	16	7.5																		

TABLE XXXIX.

CENTURY TABLE FOR LUNI-SOLAR RECKONING. (JACOBI.)

Profr. Jacobi's Table 6 in the "Indian Antiquary," Vol. XVII., p. 164, for "Centuries intervening between the given year and the corresponding one of the 19th century"—extended backwards to 500 B.C., with addition of columns showing the years for which (inclusive) the entries are to be used.

The Table applies to the years (inclusive). Expired year of the Kaliyuga.	The Table applies to the years (inclusive). Christian year.	Century.	"w"	"a"	"b"	"c"
1	2	3	4	5	6	7
	B.C.					
2602–2701	500– 401	23	0	7844	780	88
2702–2801	400– 301	22	6	6375	330	86
2802–2901	300– 201	21	5	4907	880	83
2902–3001	200– 101	20	4	3438	430	81
3002–3101	100– 1	19	3	1969	980	78
	A.D.					
3102–3201	1– 100	18	2	500	530	76
3202–3301	101– 200	17	1	9032	80	74
3302–3401	201– 300	16	0	7563	630	71
3402–3501	301– 400	15	6	6094	180	69
3502–3601	401– 500	14	5	4626	730	67
3602–3701	501– 600	13	4	3157	280	64
3702–3801	601– 700	12	3	1688	830	62
3802–3901	701– 800	11	2	220	380	59
3902–4001	801– 900	10	1	8751	930	57
4002–4101	901–1000	9	0	7282	480	55
4102–4201	1001–1100	8	6	5813	30	52
4202–4301	1101–1200	7	5	4345	580	50
4302–4401	1201–1300	6	4	2876	130	47
4402–4501	1301–1400	5	3	1407	680	45
4502–4601	1401–1500	4	2	9939	230	43
		OLD STYLE.				
4602–4701	1501–1600	3	1	8470	785	40
4702–4801	1601–1700	2	0	7001	335	38
4802–4901	1701–1800	1	6	5533	885	35
		NEW STYLE.				
4602–4701	1501–1600	3	5	5084	422	13
4702–4801	1601–1700	2	4	3615	972	11
4802–4901	1701–1800	1	2	1808	486	5
4902–5001	1801–1900	—	0	0	0	0
5002–5101	1901–2000	—	5	8192	514	995

TABLE XL.

B.C. Year Table for luni-solar reckoning.

Jacobi's Table 5 ("Indian Antiquary," Vol. XVII., p. 163) for years of the 19th century A.D., adapted for years B.C.

Odd years of a century B.C.	Corresponding year of 19th century in Jacobi's Table 5.	Odd years of a century B.C.	Corresponding year of 19th century in Jacobi's Table 5.	Odd years of a century B.C.	Corresponding year of 19th century in Jacobi's Table 5.
For B.C.	use *Table* 5.	*For B.C.*	use *Table* 5.	*For B.C.*	use *Table* 5.
100 ..	1801	67 ..	1834	34 ..	1867
99 ..	1802	66 ..	1835	*33 ..	1868
98 ..	1803	*65 ..	1836	32 ..	1869
*97 ..	1804	64 ..	1837	31 ..	1870
96 ..	1805	63 ..	1838	30 ..	1871
95 ..	1806	62 ..	1839	*29 ..	1872
94 ..	1807	*61 ..	1840	28 ..	1873
*93 ..	1808	60 ..	1841	27 ..	1874
92 ..	1809	59 ..	1842	26 ..	1875
91 ..	1810	58 ..	1843	*25 ..	1876
90 ..	1811	*57 ..	1844	24 ..	1877
*89 ..	1812	56 ..	1845	23 ..	1878
88 ..	1813	55 ..	1846	22 ..	1879
87 ..	1814	54 ..	1847	*21 ..	1880
86 ..	1815	*53 ..	1848	20 ..	1881
*85 ..	1816	52 ..	1849	19 ..	1882
84 ..	1817	51 ..	1850	18 ..	1883
83 ..	1818	50 ..	1851	*17 ..	1884
82 ..	1819	*49 ..	1852	16 ..	1885
*81 ..	1820	48 ..	1853	15 ..	1886
80 ..	1821	47 ..	1854	14 ..	1887
79 ..	1822	46 ..	1855	*13 ..	1888
78 ..	1823	*45 ..	1856	12 ..	1889
*77 ..	1824	44 ..	1857	11 ..	1890
76 ..	1825	43 ..	1858	10 ..	1891
75 ..	1826	42 ..	1859	*9 ..	1892
74 ..	1827	*41 ..	1860	8 ..	1893
*73 ..	1828	40 ..	1861	7 ..	1894
72 ..	1829	39 ..	1862	6 ..	1895
71 ..	1830	38 ..	1863	*5 ..	1896
70 ..	1831	*37 ..	1864	4 ..	1897
*69 ..	1832	36 ..	1865	3 ..	1898
68 ..	1833	35 ..	1866	2 ..	1899
				*1 ..	1900

Years marked with an asterisk (*) are leap-years.

TABLE XLI.A.

The European Julian and Gregorian Calendars.

Centuries.

	B.C.							Odd years of centuries.				A.D. Old Style.							A.D. New Style.				
	2700 2000 1300 600	2600 1900 1200 500	2500 1800 1100 400	3100 2400 1700 1000 300	3000 2300 1600 900 200	2900 2200 1500 800 100	2800 2100 1400 700 0					0 700 1400	100 800 1500	200 900 1600	300 1000 1700	400 1100 1800	500 1200 1900	600 1300 2000	Sa 1600 2000	Fr 1700 2100	W 1800 2200	Mo 1500 1900 2300	
	Initial Days.											Initial days.											
	Fr	Th	W	Tu	Mo	S	Sa	0	28	56	84	Th	W	Tu	Mo	S	Sa	Fr	Sa	Th	Tu	S	L.Y.
L.Y.	W	Tu	Mo	S	Sa	Fr	Th	1	29	57	85	Sa	Fr	Th	W	Tu	Mo	S	Mo	Sa	Th	Tu	
	Tu	Mo	S	Sa	Fr	Th	W	2	30	58	86	S	Sa	Fr	Th	W	Tu	Mo	Tu	S	Fr	W	
	Mo	S	Sa	Fr	Th	W	Tu	3	31	59	87	Mo	S	Sa	Fr	Th	W	Tu	W	Mo	Sa	Th	
	S	Sa	Fr	Th	W	Tu	Mo	4	32	60	88	Tu	Mo	S	Sa	Fr	Th	W	Th	Tu	S	Fr	L.Y.
L.Y.	Fr	Th	W	Tu	Mo	S	Sa	5	33	61	89	Th	W	Tu	Mo	S	Sa	Fr	Sa	Th	Tu	S	
	Th	W	Tu	Mo	S	Sa	Fr	6	34	62	90	Fr	Th	W	Tu	Mo	S	Sa	S	Fr	W	Mo	
	W	Tu	Mo	S	Sa	Fr	Th	7	35	63	91	Sa	Fr	Th	W	Tu	Mo	S	Mo	Sa	Th	Tu	
	Tu	Mo	S	Sa	Fr	Th	W	8	36	64	92	S	Sa	Fr	Th	W	Tu	Mo	Tu	S	Fr	W	L.Y.
L.Y.	S	Sa	Fr	Th	W	Tu	Mo	9	37	65	93	Tu	Mo	S	Sa	Fr	Th	W	Th	Tu	S	Fr	
	Sa	Fr	Th	W	Tu	Mo	S	10	38	66	94	W	Tu	Mo	S	Sa	Fr	Th	Fr	W	Mo	Sa	
	Fr	Th	W	Tu	Mo	S	Sa	11	39	67	95	Th	W	Tu	Mo	S	Sa	Fr	Sa	Th	Tu	S	
	Th	W	Tu	Mo	S	Sa	Fr	12	40	68	96	Fr	Th	W	Tu	Mo	S	Sa	S	Fr	W	Mo	L.Y.
L.Y.	Tu	Mo	S	Sa	Fr	Th	W	13	41	69	97	S	Sa	Fr	Th	W	Tu	Mo	Tu	S	Fr	W	
	Mo	S	Sa	Fr	Th	W	Tu	14	42	70	98	Mo	S	Sa	Fr	Th	W	Tu	W	Mo	Sa	Th	
	S	Sa	Fr	Th	W	Tu	Mo	15	43	71	99	Tu	Mo	S	Sa	Fr	Th	W	Th	Tu	S	Fr	
	Sa	Fr	Th	W	Tu	Mo	S	16	44	72	100	W	Tu	Mo	S	Sa	Fr	Th	Fr	W	Mo	Sa	L.Y.
L.Y.	Th	W	Tu	Mo	S	Sa	Fr	17	45	73		Fr	Th	W	Tu	Mo	S	Sa	S	Fr	W	Mo	
	W	Tu	Mo	S	Sa	Fr	Th	18	46	74		Sa	Fr	Th	W	Tu	Mo	S	Mo	Sa	Th	Tu	
	Tu	Mo	S	Sa	Fr	Th	W	19	47	75		S	Sa	Fr	Th	W	Tu	Mo	Tu	S	Fr	W	
	Mo	S	Sa	Fr	Th	W	Tu	20	48	76		Mo	S	Sa	Fr	Th	W	Tu	W	Mo	Sa	Th	L.Y.
L.Y.	Sa	Fr	Th	W	Tu	Mo	S	21	49	77		W	Tu	Mo	S	Sa	Fr	Th	Fr	W	Mo	Sa	
	Fr	Th	W	Tu	Mo	S	Sa	22	50	78		Th	W	Tu	Mo	S	Sa	Fr	Sa	Th	Tu	S	
	Th	W	Tu	Mo	S	Sa	Fr	23	51	79		Fr	Th	W	Tu	Mo	S	Sa	S	Fr	W	Mo	
	W	Tu	Mo	S	Sa	Fr	Th	24	52	80		Sa	Fr	Th	W	Tu	Mo	S	Mo	Sa	Th	Tu	L.Y.
L.Y.	Mo	S	Sa	Fr	Th	W	Tu	25	53	81		Mo	S	Sa	Fr	Th	W	Tu	W	Mo	Sa	Th	
	S	Sa	Fr	Th	W	Tu	Mo	26	54	82		Tu	Mo	S	Sa	Fr	Th	W	Th	Tu	S	Fr	
	Sa	Fr	Th	W	Tu	Mo	S	27	55	83		W	Tu	Mo	S	Sa	Fr	Th	Fr	W	Mo	Sa	

To find the initial day of any given year run the eye down the column standing under the number cf the given century in the heading, and run it across from the number cf the given odd year. The week-day found at the junction of these lines was the initial day of the year. Having obtained this, look for that week-day in the second column from the left of the heading of Table XLI.B; and in the same horizontal line, above the column which contains the day of the month will be found the week-day of that day of the month. Thus—

Wanted the week-day of March 23rd, A.D. 645. Under "600" A.D. in the heading of Table XLI.A, and in the same horizontal line with "45" in the middle, we find that Saturday was the initial day of the year A.D. 645. The year was a common one, and we read the months on the left side of Table XLI.B. We find March 23rd, and run the eye up the column in which it appears to the week-day noted in the same horizontal line as the initial day "Sat." in column 2 of the heading. We find this day to be "W." Accordingly March 23rd A.D. 645, was a Wednesday.

In the New Style A.D. the years 1600 and 2000 are Leap-years. 1700, 1800, 1900 are common years Each whole-century-year begins with the week-day entered at the top, but for all other years the Table is to be used as directed above, *e.g.*, A.D. 1900 began on Monday (top), 1901 began on Tuesday. and all other years of that century as found by the main Table. 1928 begins on Sunday.

TABLE XLI.B.

THE EUROPEAN CALENDAR.
WEEK-DAYS FOR ONE YEAR.
This Table applies equally to Old Style and New Style dates.

In Common Years the months are to be read on this side.	S. Mo. Tu. W. Th. Fr. Sa.	Mo. Tu. W. Th. Fr. Sa. S.	Tu. W. Th. Fr. Sa. S. M.	W. Th. Fr. Sa. S. Mo. Tu.	Th. Fr. Sa. S. Mo. Tu. W.	Fr. Sa. S. Mo. Tu. W. Th.	Sa. S. Mo. Tu. W. Th. Fr.	In Leap Years the months are to be read on this side.
January .. October ..	1	2	3	4	5	6	7	January. April. July.
	8	9	10	11	12	13	14	
	15	16	17	18	19	20	21	
	22	23	24	25	26	27	28	
	29	30	31	—	—	—	—	
February . March .... November.	—	—	—	1	2	3	4	February. August.
	5	6	7	8	9	10	11	
	12	13	14	15	16	17	18	
	19	20	21	22	23	24	25	
	26	27	28	29	30	31	—	
April ..... July	—	—	—	—	—	—	1	September. December.
	2	3	4	5	6	7	8	
	9	10	11	12	13	14	15	
	16	17	18	19	20	21	22	
	23	24	25	26	27	28	29	
	30	31	—	—	—	—	—	
August ...	—	—	1	2	3	4	5	May.
	6	7	8	9	10	11	12	
	13	14	15	16	17	18	19	
	20	21	22	23	24	25	26	
	27	28	29	30	31	—	—	
September December	—	—	—	—	—	1	2	June.
	3	4	5	6	7	8	9	
	10	11	12	13	14	15	16	
	17	18	19	20	21	22	23	
	24	25	26	27	28	29	30	
	31	—	—	—	—	—	—	
May	—	1	2	3	4	5	6	October.
	7	8	9	10	11	12	13	
	14	15	16	17	18	19	20	
	21	22	23	24	25	26	27	
	28	29	30	31	—	—	—	
June	—	—	—	—	1	2	3	March. November.
	4	5	6	7	8	9	10	
	11	12	13	14	15	16	17	
	18	19	20	21	22	23	24	
	25	26	27	28	29	30	31	

TABLE XLI.C.

THE SERIAL NUMBER OF DAYS IN A YEAR A.D., FOR FINDING THE DAY OF MĒSHA SAṀKRĀNTI

After February 29th in a Leap-year the number of the day must be advanced by 1. *March 1st in a Leap-year is No.* 61, *&c.*

Day of month	Jan.	Feb.	Mar.	Apr.
1	1	32	60	91
2	2	33	61	92
3	3	34	62	93
4	4	35	63	94
5	5	36	64	95
6	6	37	65	96
7	7	38	66	97
8	8	39	67	98
9	9	40	68	99
10	10	41	69	100
11	11	42	70	101
12	12	43	71	102
13	13	44	72	103
14	14	45	73	104
15	15	46	74	105
16	16	47	75	106
17	17	48	76	107
18	18	49	77	108
19	19	50	78	109
20	20	51	79	110
21	21.	52	80	111
22	22	53	81	112
23	23	54	82	113
24	24	55	83	114
25	25	56	84	115
26	26	57	85	116
27	27	58	86	117
28	28	59	87	118
29	29	60	88	119
30	30		89	120
31	31		90	

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